THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL.

VOL. 30. Thursday, October 23, 1924. No. 427.

PUBLISHED WEEKLY.

Subscription Terms: 15s. per annum.

Foreign and Colonial, 17s. 6d. per annum.

All Subscriptions are payable in advance.

All communications to be addressed to the Editor, or to the Publisher, as the case may be, of

THE FOUNDRY TRADE JOURNAL,
BESSEMER HOUSE, 5, DUKE STREET, ADELPHI,
LONDON, W.C.2.

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Forthcoming Events.

OCTOBER 24.

Institution of Mechanical Engineers:—General meeting in London. "The Missing Pressure in Gas Engines, and Heat Loss in Gas Engines." Paper by Professor W. T. David, M.A., Sc.D.

OCTOBER 28.

Sheffield Metallurgical Association:—Ordinary meeting at Sheffield. "Body in Steel," Paper by J. Kent Smith, O.B.E.

Institution of Automobile Engineers:—Informal meeting in London.

NOVEMBER 1.

Institute of British Foundrymen (Lancashire Branch):—Ordinary meeting at Manchester. "Modern Pattern-making Experience." Paper by J. A. Stephenson.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

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German Foundry Conditions.

We have recently had an opportunity of inspecting a number of German iron and steel foundries, but as the German foundry industry is widely distributed it was impossible in the time at our disposal to make an extended tour, and our deductions may not universally apply.

Trade is undoubtedly in a very depressed condition, mainly owing to the shortage of money. The moulders in the factories visited receive 75 pfennigs an hour, and work as long as they like or are required. Although trade is so slack, a number of new foundries are being built, extensions being carried out, and new plant installed.

More attention is given to the magnetic separation of iron from old moulding sand than is usual in this country. The makers of the plant instal it free of cost, and take in payment a percentage of the iron recovered, which is sold to the blast furnaces. On a weight basis, 5 per cent. is the normal amount recovered, but 10 per cent. is said to be quite usual in American practice.

The drying of moulds is often carried out by a portable stove of the type recently described by Mr. Barlow, of Edgar Allens, in a Paper given to the Engineering Societies' Conference, and published in THE FOUNDRY TRADE JOURNAL.

For the cleaning of castings, the sand-blast plant is popular and in general well constructed, but for the grinding and tumbling the plants we saw did not represent the latest and best British practice, though no doubt other foundries may be better equipped. It seems that the health and safety conditions in German foundries are regulated by an association of insurance companies, but we understand their recommendations are likely to become law in the near future.

We received the impression that normal German cupola practice is not conducted with so low a coke to iron ratio as we associate with the best British practice, but the coke available is of a poorer quality.

The smaller yet important items in foundry practice, which nowadays are termed "gadgets," show, perhaps, less initiative in German than in either French, Belgian or British practice. For instance, moulding-box fitments are not at all modern, whilst the ladles are definitely of poorer construction than is usual in Belgium.

Practically every cupola we inspected was equipped with a tapping device, and this can now be regarded as normal German practice. It is without doubt an improvement on the age-old system of "botting in."

Moulding machines, supplemented by pneumatic rammers, are extensively used, every type being well represented.

An improvement in trade is expected in a section of the Western German foundries when the "Franco-Belgian Regie" hands over the engineering control of the railways, as but little money has been spent in maintenance for some considerable time.

German foundries are in a splendid condition to take advantage of the latest developments, as they are adequately provided with chemical and physical testing laboratories, well seconded by technical colleges. The German ironfounders are 100 per cent. organised, and *do not suffer from the avoidable competition of ill-conducted foundries using obsolete costing systems.* They have a standardised, highly-perfectioned costing system, which every foundry uses. If such a system could be nationally operated in Great Britain it would do more good for the trade than anything that has been devised for its welfare since Wilkinson invented the cupola.

XUM

Making Copper Castings from Cupola Melted Metal.*

By T. F. Jennings, Garfield, Utak.

The casting of copper in sand moulds has always been attended with considerable difficulty because of the fact that copper, like most elementary metals, absorbs gases while it is being melted. These gases being retained after the metal becomes solid produce a structure resembling a sponge, and the defect for that reason is known as sponginess. This difficulty, being productive of unsatisfactory results, has created a certain prejudice against the use of the metal in the minds of some foundrymen, which is entirely unjustified. There is no reason why copper castings cannot be produced just as easily and readily as castings of iron, or any other metal, if certain fundamental facts, peculiar to the metal while in the molten state, are observed. For acid-resisting purposes it is the opinion of the writer, that approximately 50 per cent. of the castings made in iron should be made of copper. It is tougher than iron, and can be made quite hard.

Common Causes of Defects in Copper Castings.

Sponginess, blowholes, porous or unsound castings are the usual causes of rejections in the case of copper castings. Occasionally, castings of this character can be used; but as a general rule they are unfit for practical use, and if their true character is not discovered before they are placed in service, they are liable to cause trouble, expensive delays, and perhaps serious accident.

Pores or blowholes in castings, sometimes are caused by wet or hard-rammed moulds, or cores. The principal cause, however, lies in the metal itself, for it is a peculiar fact, that copper, like a number of other elementary metals, and some alloys also, melting above 1,000 degs. C., when cast in sand moulds will produce gaseous castings. This condition will occur, no matter how carefully they may be melted and handled, unless some metal or flux is added to the melt to "deoxidize it," as it is termed.

Need for Deoxidizers.

The substance with which the copper is treated is generally known as a "deoxidizer," that is, an oxygen remover, which would lead to the supposition that oxygen was the gas responsible for the porous condition of the metal. There appears reason to believe, though, that sulphur has an important part in the production of the gas, as sulphur and oxygen react and form the gas, sulphur dioxide, which if generated within the molten metal might be retained and so produce this condition of porosity.

While it is not the intention of the author of this paper to enter into a discussion concerning identity of the gases responsible for the unsoundness of the castings, as it is a subject he has not taken the time to study, it will be evident that it is advisable whenever copper is being melted for castings, that it be protected as much as possible from contamination by both sulphur and oxygen.

Furnace Factors.

Accordingly many foundrymen prefer to melt their copper in crucibles, as it is comparatively quite easy to protect it with a covering of charcoal, or of some suitable flux, especially when natural-draft melting furnaces using solid fuel, are the melting medium. In the case of oil or gas-fired furnaces even with crucibles it is less easy to protect the metal from the gases, as the force of the flame blows away the charcoal covering, making it necessary to use something of the order of a flux that will melt and cover the surface of the metal, and which will not be displaced by the force of the blast. When melting with non-crucible furnaces consuming oil or gaseous fuels, it is more difficult to protect the copper than it is in the case of the crucible furnaces, as there is intimate contact between the flame and the metal. Electric furnaces should theoretically be excellent melting mediums for copper, as the furnace can be worked closed or open as thought best. The cupola furnace, as used for cast iron, has the reputation of being the most satisfactory melting medium that can be used for copper, and most non-ferrous alloys, as the metal, fuel and air blast are in intimate contact during the entire melting period. Many foundrymen are of the opinion that this furnace cannot be used for melting such metals and alloys.

Use of the Cupola in Melting Copper.

As the author has had considerable experience in making light and also heavy copper castings from cupola-melted metal, it may be of interest to give an outline of the methods used, as some of the copper castings made from the cupola have weighed up to five thousand pounds, with walls from three to seven inches in thickness, and about forty per cent. were finished all over on the outside.

Cupola Preparation.

The cupola used was a No. 3 Whiting cupola, which was put up in the same manner as for an iron heat, except that care was taken to have the wood used to start the fire on the bottom, free of all iron, in the shape of nails. This is a precaution that should always be taken when non-ferrous metals are to be melted. It is, of course, unnecessary in the case of iron melting, but important for copper, and is mentioned at length because it is one of those little things, necessary for success, so easily overlooked. In order to protect the copper as much as possible from the sulphur in the coke, it was sandwiched between layers of charcoal: thus instead of charging copper directly on top of the coke bed, the charges were made as follows: The bed charge consisted of 600 lbs. coke, 45 lbs. charcoal, and 1,250 lbs. copper. The charges following the bed consisted of 45 lbs. charcoal, 60 lbs. coke, 45 lbs. charcoal, and 1,250 lbs. copper. The entire amount of copper for each heat was thus protected by layers of charcoal from the sulphur contained in the coke. A mild blast was employed, 8 ozs., and the slag hole was not opened during any of the heats which ran about 15,000 lbs. each.

Calcium Chloride Used as a Fluid Slag.

A high percentage of copper wire was used in the charges and 15,000 lbs. heats were run in from one hour to one hour and fifteen minutes. After the copper was melted it was tapped into a ladle of suitable size, which had been previously heated with an ordinary ladle torch-heater, for about one-half hour. About 10 mins. before the metal was tapped into the ladle about 0.5 per cent. of calcium chloride was placed in the bottom, which when the copper is tapped on to it makes an absolutely air-tight covering.

Precautions when Using Calcium Chloride.

This chemical, however, must be used with caution as it contains water, as water of crystallization, and in addition it absorbs water from the atmosphere when exposed thereto, which would cause an explosion if the chloride was submerged in the copper, as it would be if dropped into it. By adding it in the bottom of the heated ladle the water is driven off and there is no danger of metal flying. In addition to the calcium chloride, a generous layer of charcoal is placed in the ladle immediately before the furnace is tapped. A few handfuls of silica sand was thrown in the lips and stirred in well to stiffen the slag.

Phosphor Copper as a Deoxidizer.

The deoxidizer used was one per cent. of 15 per cent. phosphor-copper. The metal was dealt with in 5,000 lb. ladles and was drawn in three taps; after the first tap the phosphor-copper was added, the slag cover stuck close to the sides of the ladle and the phosphor-copper kept from evaporating

* A Paper read before the Milwaukee Meeting of the American Foundrymen's Association.

and the two following taps it was mixed well without stirring or poling. To avoid the fumes and smoke and have prompt crane service, the metal was brought down after the whistle blew, and was carried from cupola to the moulds in about one minute and poured it at about 1,065 deg. C.

Pouring Precautions.

In pouring the castings the rate of pouring was diminished just before the mould was filled. Whenever heavy risers had to be put on, a small piece of phosphor-copper was always dropped into each one and the riser was churned until it set; the hot metal to supply the shrinkage during the churning being obtained from a Hawley Swartz small furnace, run especially for the purpose.

Sand and Moulds.

An open facing was used composed of half red-sand and half sharp-sand and one to twenty (1 to 20) of core compound. No coke dust was used on account of gas and sulphur. In ramming the moulds the rammer was always kept about one inch away from the pattern, and the moulds were very thoroughly and carefully vented.

In making heavy castings of copper, the practice has always been to dry the moulds, and to pour them from the bottom, using cores to carry the metal down and into the mould cavity.

Hardening Copper.

When the copper castings are to be used for "acid-resisting" purposes, or where hard wearing qualities were demanded, it has been our custom to add from 2 to 4 per cent. of an alloy composed of 16 per cent. chromium and 1 per cent. phosphorus, the balance being copper. This alloy is made in a crucible steel melting furnace, the chromium being melted first, as a high temperature is required to melt the chromium. There are but two well-known methods of hardening copper; namely, by mechanically working it, and by the addition of some alloying element.

Pouring Heavy Copper Castings.

When pouring the moulds for heavy copper castings it is necessary to keep the pouring basin full of metal all the time the mould is taking metal; great care being necessary to guard against the metal sucking air into the mould with it, as under certain conditions it forms gas, which being absorbed by the molten copper, causes "spewing up" in the risers.

Both large and small copper castings are most frequently made in sand moulds, though iron moulds are sometimes found desirable for casting terminals for electric furnaces using large amounts of currents, more especially when heavy copper cables are cast therein.

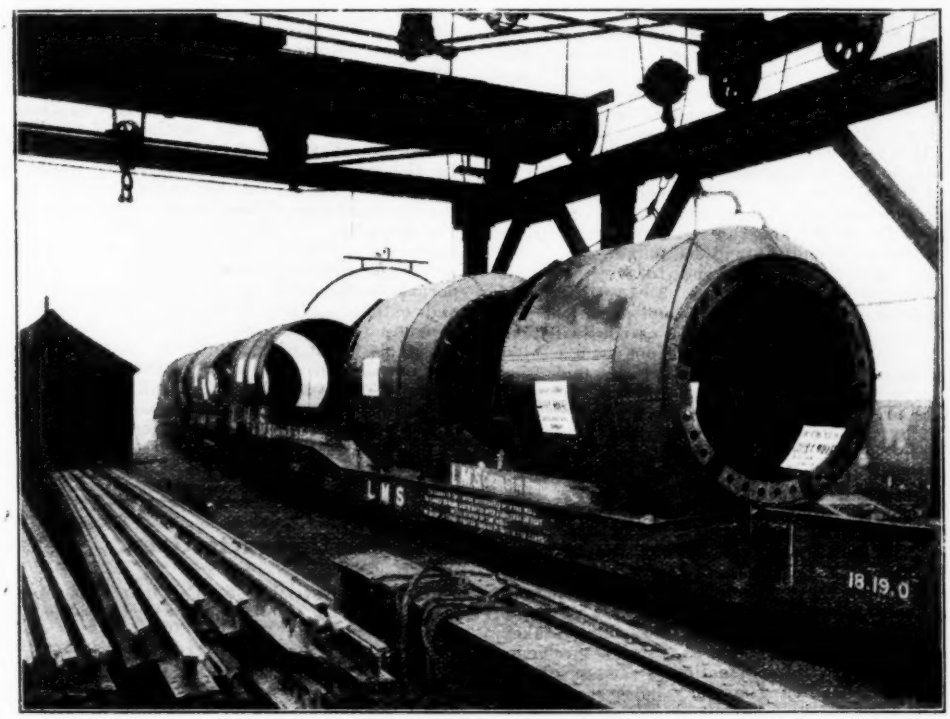
Skilful Operation Necessary.

To succeed in getting sound copper castings the melting has to be carefully and skilfully conducted, *no matter what kind of a furnace is used.* This applies to the cupola, probably more than with any other furnace, and the method the author has attempted to outline has given very good results. The castings made were not intended to be used for purposes where high electrical conductivity was important, otherwise, the phosphor copper could not have been used as a deoxidizer, and as a consequence it might have been more difficult to eliminate the gases and obtain sound castings. This we do not know, as it has not been necessary to make such castings.

Brass castings can also be made from cupola-melted metal, if the same precautions as described are used in melting the copper. The zinc, however, should be added in the ladle. To prevent chilling of the copper, the zinc must be pre-heated to a temperature just below the melting point. In the case of either brass or copper it is necessary to have it hot, when it is melted in a cupola furnace.

A Large Cupola.

In a recent issue we reported the despatch of a large cupola manufactured by the Constructional Engineering Company, of Birmingham, to a foundry at Bonnybridge, Scotland. The accompanying illustration gives some idea of its size, and one can readily understand that special arrangements had to be made with the railway companies.



THE DESPATCH OF A LARGE CUPOLA.

Foundry Query.

Vanadium in Cast Iron.

Can you tell me the effect the introduction of ferro-vanadium, say, 1 per cent., would have on a No. 3 Staveley, Derbyshire, iron, and in your opinion what would be the best way to introduce it?—H. S.

Contraction and Warping in Castings.*

By J. Gray.

The two terms contraction and warping are very closely related, and the latter may be sub-divided into liquid and solid contraction. Both are reductions in the volume of the material, while warping may be described as the result of irregular reduction in volume. Liquid contraction or shrinkage is the decrease in volume of molten metal from the time of pouring till the point at which it becomes solid. Solid contraction is the lessening of the volume of metal from the point of solidification during cooling, while warping is the result of unequal contraction, due, as a rule, to the design of a casting. We cannot say that these occurrences, and the several annoying results accruing from them, are due to bad practice; neither can we say that they cannot be avoided. We certainly must treat them as natural occurrences and take steps to remedy them, either by treatment of the mould in its construction or in the pouring of the molten metal and in its composition.

Solid contraction has the peculiarity of being uniform in some metals, such as aluminium, lead, tin, etc., and not uniform in others, such as steel, white iron, and cast iron. We therefore must conclude that contraction varies with the character of the metal. The explanation of this is that certain metals in cooling pass through certain critical points, purely functions of composition. High phosphoric cast iron is perhaps the most interesting metal in this respect, as on cooling at 1,130 deg. C., it solidifies, and free carbon is thrown out as flakes of primary graphite. In cast iron at 860 deg. C., compounds separate out in the metal, such as iron, phosphorus, carbon, etc., and at 730 deg. C. the iron becomes magnetic and secondary graphite is precipitated. Now all these changes produce expansion in the metal, causing a retardation of contraction.

With regard to solid contraction and how it may be met, it may be mentioned that steel is a difficult metal in this respect, as the contraction in steel is high, being 3/16-in. per ft. Assuming a steel liner to be 30 ft. long by 3 ft. in dia., with a flange on each end, it will be found that, after casting, each flange will tend to move towards the centre, a distance of 2 13/16 in. If the character of the mould does not permit of this movement, then distortion of the casting will take place. Cast iron or brass have not such a high contraction, the amount being 1/10-in. and $\frac{1}{8}$-in. per ft. respectively. All green-sand and dry-sand moulds are capable of being compressed by the metal, but where intricate forms are concerned solid contraction must be considered. Take, for instance, the main bore of a cylinder, 8 ft. dia., built with the ordinary clay brick. This core would require attention, and it would be essential that all cores making up this mould should have a good supply of cinders, or in the case of a jacket core, straw could be applied.

Solid contraction, therefore, we must conclude is an important item in steel, but in cast iron and brass, although it is natural and always takes place, cannot be looked upon as a serious problem. The sequence to solid contraction is a more serious proposition. Let us consider, however, for a moment what we know about shrinkage or liquid contraction in metals. In this connection we may note that all metals have a definite range of fluidity from the time of pouring until solidification. In the first place, steel has an exceedingly short range, hence the necessity for a great head of metal above the casting. Cast iron has a long range, and brass a still longer range. Generally speaking a mass of molten metal after pouring solidifies against the cooling surfaces, forming a solid shell. Layer upon layer grows upon this shell, until all the metal has solidified. Shrinkage being natural, has taken place, and most assuredly a cavity or depression has been left in the centre or last part to solidify. We can follow from this that shrinkage can only be met by a further supply of molten metal after pouring through a feeding head.

As an illustration take, for instance, a propeller boss in cast iron 8 tons in weight. It would require the usual risers and a fair receiver to hold the metal which would pass through the casting. Molten metal would be supplied at each riser by hand ladles, the rod for feeding being of the ordinary material. This would get over the deficit which would certainly be caused by shrinkage. Shrinkage in cast iron is troublesome, and the same may be said of the majority of alloys. In brass, and all metals having a long range of fluidity, it is possible to feed them by varying methods. It is safe to say that all copper zinc and copper tin alloys can be cast without feeding, as is proved any day in any marine brass foundry, but special castings and alloys require special treatment. It will therefore be seen that the heavier the section there is the greater necessity to feed, as the law of molecular vibration comes into operation in thick sections.

In dealing with the results of solid contraction reference should be made to warping, which is really due to irregular contraction. That is to say, if the contraction does not occur naturally the casting twists and breaks. It therefore must have special attention. Such an occurrence is, no doubt, annoying and sometimes very difficult to remedy. The different thicknesses of metal in a casting induces warping, owing to the different rates of contraction, and again, long flat castings, when poured, tend to lift at the ends. It is obvious in such case that the remedy lies in setting the pattern out of truth and so ensuring that it will be straight when cold. Lathe beds are good examples of this, but in the writer's opinion, experience in cambering by trials and error is the only remedy. Existing knowledge on this subject is at best empirical, as so many points crop up in retarded contraction which makes it impossible to devise laws.

Warping is rather a difficult matter to illustrate practically. In long flat castings, if the lift be known, an allowance of $\frac{1}{8}$-in. in 6 ft. is imperative. In the majority of castings warping would take place if precaution was not taken, but we rely on the practical experience of craftsmen to get over the difficulty. In the case of a pulley wheel with heavy hub, thinner arms, and a very thin rim, shrinkage and contraction take place at different periods in the three parts, both in regard to rate and extent. That is to say one part may be expanding while another is contracting, so that the whole is out of equilibrium. One can imagine the internal stresses set up, and if the arm of any pulley wheel be broken, it will be found almost impossible to fit the broken portion. The equalising of cooling is, of course, the remedy, by chilling or other means, but that is without the scope of the present subject.

* Report of a paper read to the Institute of British Foundrymen (Scottish Branch) on Saturday, October 11, 1924. For this paper Mr. J. Gray, of Dumbarton, was awarded the gold medal in the senior examination held under the "John Surtees Memorial."

Contracts Open.

Blackpool, November 5.—Cast-iron segments for lining about 710 ft. of 18 ft. diameter tunnel. The approximate weight will be 1,070 tons for straight sections and 190 tons for curved sections. Mr. G. F. Atkinson, engineer, Sefton Street, Blackpool.

Bodmin, November 4.—About 2,500 tons of cast-iron pipes from 9 in. to 3 in. diameter, for the North Cornwall Joint Water Board. The engineer to the Board, Capt. C. J. Jenkin, 91, Old Town Street, Plymouth. (Fee, £2 (cheque only), returnable.)

Singapore, October 31.—About six miles of welded steel pipe, 33 in., 36 in. and 39 in. internal diameter; together with certain cast-iron pipes, valves and specials, for the Municipality of Singapore. Sir Alex. Binnie, Son & Deacon, 30, Buckingham Gate, Westminster, London, S.W.1. (Fee, £5, returnable.)

Bloemfontein, S.A., December 1.—Piping, pumps, etc., for the Municipality of Bloemfontein. The Department of Overseas Trade, 35, Old Queen Street, London, S.W.1.

The record for one week's production was broken at the Frodingham Iron and Steel Company's works at Scunthorpe last week, when 6,193 tons of steel were turned out from six furnaces, two of which are of small size.

Notes on Composition and Structure of A.S.T.M. Bar.*

By J. W. Bolton, Hamilton, Ohio.

INTRODUCTORY.

Accurate knowledge of the relation-hips between the composition of cast irons and their strength is desired by all foundries exercising intelligent metallurgical control of their product. Unfortunately, there are other variables which often mask the real influences of composition. Study of the structure of the metal often explains such seeming discrepancies. In this paper the writer has attempted to show some effects of variation in composition and structure on properties of the standard A. S. T. M. bar. While conditions are different in every shop, it is thought that curves covering the same type mixtures in other shops will probably parallel, if not duplicate, the charts given here. Some variations which affect results in this type of work are:

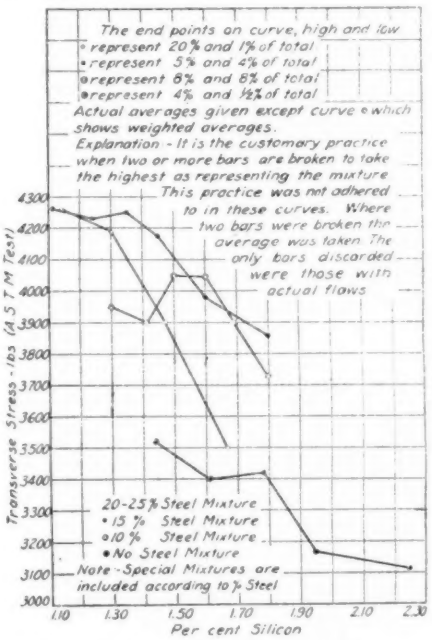

The end points on curve, high and low
represent 20% and 1% of total
represent 5% and 4% of total
represent 8% and 8% of total
represent 4% and ½% of total
Actual averages given except curve ○ which shows weighted averages.
Explanation - It is the customary practice when two or more bars are broken to take the highest as representing the mixture
This practice was not adhered to in these curves. Where two bars were broken the average was taken. The only bars discarded were those with actual flaws
Transverse Stress - lbs (A S T M Test)
4300
4200
4100
4000
3900
3800
3700
3600
3500
3400
3300
3200
3100
3000
20-25% Steel Mixture
15 % Steel Mixture
10 % Steel Mixture
No Steel Mixture
Note - Special Mixtures are included according to % Steel
1.10
1.30
1.50
1.70
1.90
2.10
2.30
Per cent. Silicon

FIG. 1.—RELATION PER CENT. SILICON TO TRANSVERSE STRENGTH.

(1) Variations in testing due to calibration of testing machine, and personal equation of the operators. In these tests the same calibrated machine (a 50,000-pound Riehle) has been used throughout, and the same operators have conducted the tests.

(2) Variations in cupola practice, types iron and coke, make-up of mould, test bar pouring practice, are as slight as is practical since the same general practice was adhered to throughout, and

(3) Variations in the type mould and size bar. The bars from which the results were taken were of standard dimensions and were made in oil sand cores with cover cores for the gates.

Notwithstanding these precautions, some variations are unavoidable. The results on silicon and carbon charted are averages made up from 1,000 carefully tested bars, a number of which were run in duplicate. The effects of individual variations are minimized by the law of averages.

In addition to the results on silicon and carbon obtained from the regular bars, there are several micrographs and charts covering other properties of the irons. These latter were obtained from some 50 standard test bars (over a couple months' period) and a few exceptionally low and high test bars, all of which were very completely examined by analysis, physical testing and microscopy.

* A Paper presented before the Milwaukee meeting of the American Foundrymen's Association. The author is Metallurgist at the Niles Tool Works.

The foundry of the Niles Tool Works (of the Niles-Bement-Pond Company) is essentially a jobbing shop. It specialises in heavy castings of high quality. Because of its facilities for this type of work, it handles special jobs as well as the regular heavy machine tool line. Since the regular work

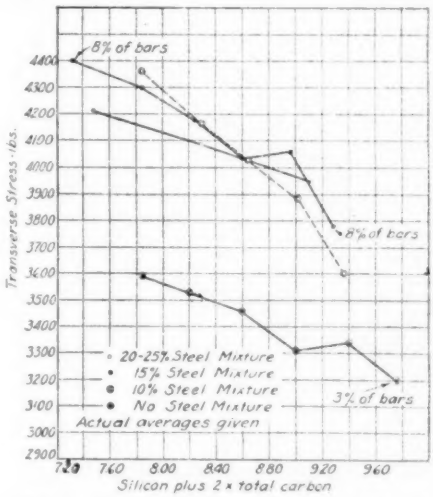


FIG. 2.—CURVES SHOWING RELATION OF TRANSVERSE STRENGTH TO THE FACTOR SILICON PER CENT. PLUS TWO TIMES THE TOTAL CARBON PER CENT.

varies in size from a few pounds to over a hundred thousand, and sections from ½ in. to 5 or 6 ins., several mixtures must be used. For the regular work four mixtures are used, while special mixtures are used for occasional jobs.

The important variables affecting strength of sound bars are graphite, combined carbon, and ferrite. These, in turn, depend largely on the silicon and total carbon. The charts show the effects of these elements, considered singly and together.

Effect of Silicon.

Decrease of strength with increase in silicon is a phenomenon familiar to all foundrymen. Fig. 1

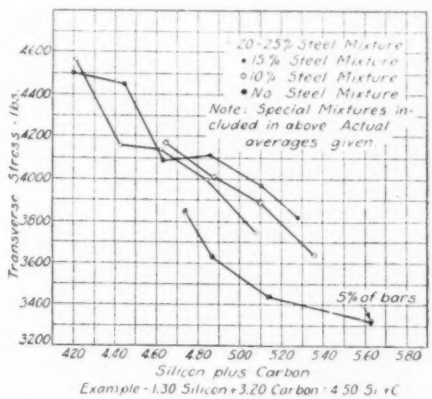


FIG. 3.—CURVES SHOWING THE RELATION BETWEEN TRANSVERSE STRENGTH AND THE FACTOR SILICON PER CENT. PLUS CARBON PER CENT.

shows the relation of per cent. silicon to the transverse strength, as shown by several commercial foundry mixtures. With the exception of curve No. 3, each curve is free from large jogs. All curves point in the same direction; that is, by

straightening the jogs on each curve, there would be four approximately parallel curves. The no steel mixtures, curve No. 4, are the lowest, then the 10 per cent. steel mixtures, curve No. 3; then the 20 to 25 per cent. steel mixtures (curve 1) and the highest is the curve No. 2 of the 15 per cent. steel mixture. The first inference is that, for the same silicon, 15 per cent. steel gives the greatest strength, while the no steel mixture is weakest. However, there are other factors which must be considered before drawing such a conclusion.

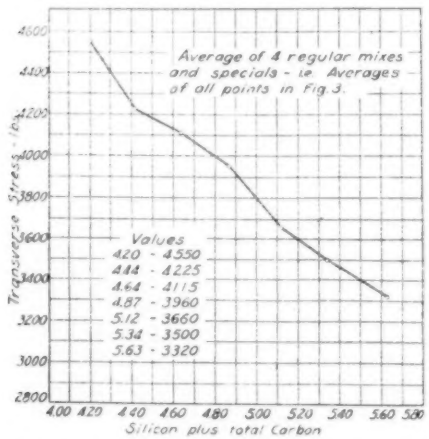

Average of 4 regular mixes and specials - ie. Averages of all points in Fig. 3.
Values
4.20 - 4.550
4.44 - 4.225
4.64 - 4.115
4.87 - 3.960
5.12 - 3.660
5.34 - 3.500
5.63 - 3.320
Transverse Stress - lbs.
Silicon plus total Carbon

Fig. 4.—Curves made from Data of Fig. 3.

The effects of the variables of cooling rate, pouring temperature, per cent. sulphur and manganese, etc., are minimised by averaging. The variables which are peculiar to the mixtures, besides silicon, are the per cent. carbon and the per cent. phosphorus; the more steel the less carbon and phosphorus. The 20 to 25 per cent. steel mixtures

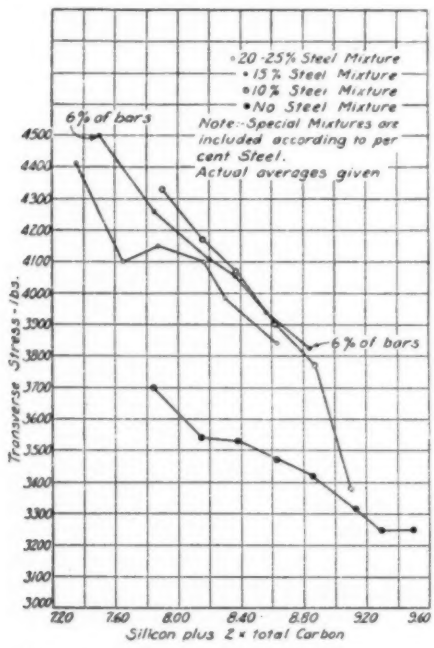

20-25% Steel Mixture
15% Steel Mixture
10% Steel Mixture
No Steel Mixture
Note:-Special Mixtures are included according to per cent Steel.
Actual averages given
6% of bars
6% of bars
Transverse Stress - lbs.
Silicon plus 2 × total Carbon

Fig. 5.—Curves showing Relation of Transverse Strength to the Factor Per Cent. Silicon plus Two Times the Total Carbon Per Cent.

normally contain more sulphur, and enough manganese for all of it to form manganese sulphide inclusions.

The only conservative conclusion that can be formed is that, for the A. S. T. M. bar equal increase in silicon effects an approximately equal amount of decrease in strength for the different mixtures. This decrease in strength seems more rapid in the higher silicon ranges of some of the mixtures examined.

Total Carbon.

Increase in the total carbon is generally thought to decrease strength. However, many foundrymen pay little attention to carbon. Fig. 2 should give these people food for thought. Curves 1, 2, and 3, covering the various steel mixtures, follow one another remarkably closely. The no-steel curve No. 4 stands by itself. An averaged curve for the three steel mixtures would enable one to predict the strength for each carbon on each steel mixture. Unfortunately, such an idea, if applied to other mixtures, would lead to grave errors. The *silicon* in these mixtures varies somewhat in the same direction as the carbon. Also, the silicon on the no-steel mixtures will average considerably

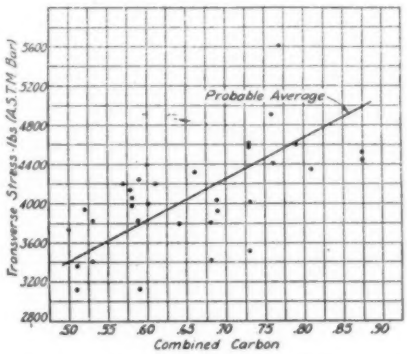


Fig. 6.—Curve showing Relation of Transverse Strength to Per Cent. Combined Carbon.

higher than that on the steel mixtures. On the mixtures given no rule for calculating strength would seem to apply to all four types of mixtures.

Silicon and Carbon.

Increase of either silicon or carbon decreases the strength. The influence of these elements is cumulative. Therefore, it is logical to consider the influence of their *sum*. This has been done in Fig. 3 and Fig. 4. The resulting curves, including that of the no-steel mixtures, are closer than those of Figs. 1 and 2, and their general direction is the

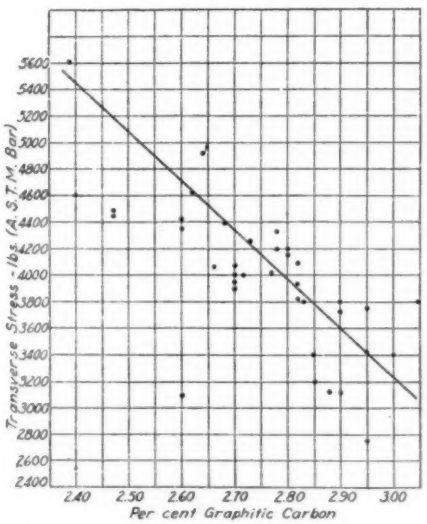


Fig. 7.—Curve showing Relation of Transverse Strength to Per Cent. Graphitic Carbon.

same. The curves of Fig. 3 led us to construct the average curve, Fig. 4. This curve, in the ranges shown, approaches a straight line. In examining these curves, it will be noted that there is much less variation between various type mixtures; the big gap between the steel and no-steel curves shown in Figs. 1 and 2 is partially bridged. It is apparent that the effect of steel *per se* is less than would seem to be the case on inspection of Figs. 1 and 2.

Silicon and Two Times Carbon.

Critical inspection of Figs. 1 and 2 seems to indicate that carbon exerts more influence than silicon. With this in mind, the chart, Fig. 5, was drawn up. It does not bridge the gap between the steel and no-steel mixtures as well as the Si plus C curves, Fig. 3.

Preliminary Conclusions.

Effects of silicon and total carbon variation have been considered first as it is through these elements that the practical foundryman is best able to *control* the physical properties of his metal. The following preliminary conclusions are justified by the experimental data presented above.

The sum, silicon plus carbon, varies inversely with the transverse test—very closely for various semi-steels, and reasonably so for regular cast iron. *This sum gives a more accurate idea of the probable strength of the A. S. T. M. bars than any other simple and inexpensive test.*

Steel seems to exert an effect on strength *per se*. The major part of the variations between results on cast irons and semi-steels can be explained by various differences in the analyses. Notwithstanding this, there remains a gap which is bridged only by assuming that the steel has some intrinsic merit besides its known effect on composition. The mere addition of steel will not raise the strength some fifty per cent. if the analysis is kept the same—but it apparently raises it 10 per cent. The writer does not believe in mysterious properties. There are some material differences in the manufacture of pig iron in the blast furnace and of steel scrap pig in the cupola.* Different processes in iron and steel manufacture give different strengths for the same analysis and many of these process effects have been explained in a satisfactory manner.

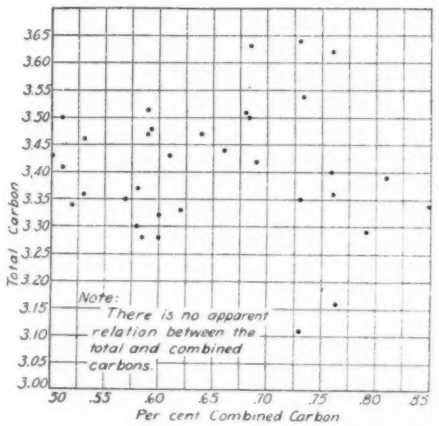


FIG. 8.—SHOWING LACK OF RELATION BETWEEN PER CENT. COMBINED CARBON AND TOTAL CARBON.

Total carbon seems to exert a greater influence on the strength of the A. S. T. M. bar than silicon; per cent. variation for per cent. variation, and in the ranges given.

Combined Carbon and Graphite.

Under like cooling conditions the silicon and total carbon practically determine the amounts of combined and graphitic carbon. From the foundryman's viewpoint, silicon and total carbon are the major controllable causes, combined and graphitic carbon an effect. Increase in combined carbon up to around 0.70 to 1.00 per cent., and decrease of graphitic carbon unquestionably tend to increase the strength. Unfortunately, there are several difficulties met when trying to draw conclusions from results on per cent. combined and graphitic carbon instead of on silicon and total carbon. First, speaking of the A. S. T. M. bar, there is no vast difference encountered in per cent. combined carbon of bars of considerable variation in strength. The best method of analysis† is subject to cumulative error. Sampling, even in the A. S. T. M. bar, must be done very carefully to get representative drillings, for the outer part of the bar contains a different amount of combined carbon than the inner portion. Then, in case of graphitic carbon, the size and distribution are as important as the amount, if not more so. The distribution of graphite in the A. S. T. M. bar is determined largely by the silicon and carbon, making it necessary to know these as well as the per cent. graphite.

Notwithstanding these objections, the apparent influence of per cent. combined and graphite carbons deserves consideration. The writer gives, in Figs. 6 and 7, results obtained from some thirty-five very carefully tested bars.

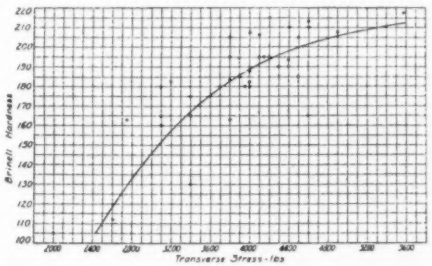


FIG. 9.—CURVE SHOWING RELATION BETWEEN BRINELL HARDNESS AND TRANSVERSE STRENGTH.

These charts indicate the increases in strength due to increase in combined carbon and decrease in graphite. Mixtures from 0 to 25 per cent. steel are listed. The writer thought there might be some relation between the per cent. total carbon and the combined carbon. This is evidently untrue for these bars, as is shown by Fig. 8. It must be remembered that increase in combined carbon increases the strength to a *maximum* at 0.70 to 1.00 per cent., from which point the strength falls off *very rapidly*. Decrease in combined carbon results in decrease of strength to a *minimum*.

Relations Between Transverse and Tensile.

Engineering formulæ consider cast iron in terms of tensile strength. This is illogical, because cast iron is rarely used in tension. Transverse and compression stresses are the common type stresses. Strength of metal is rarely a factor in design for compression stresses are the Common type stresses, are transverse, of the cantilever type. The 10 to 1 ratio is widely used to-day. It is a very convenient ratio—but it is not accurate! True enough, there are bars with a ratio 12 to 1, and a number at 10 to 1, but the majority are lower. The A. T. S. M. sets the ratio 28,000 to 3,800 or a little less than 7½ to 1. On averages of numbers of bars the writer has found that this ratio is a good one, perhaps a little conservative, but it is better to cheat oneself on the safe side than to claim and not make good. There are many bars that test over 4,500 transverse, but in commercial practice there are comparatively few A. S. T. M. bars much over 40,000 tensile. In experimental work one can get much better results. Comparisons must be on the *same basis*, the standard A. S. T. M. bar, and stunts mean little in practical work.

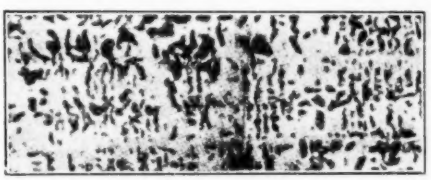


FIG. 10.—STRUCTURE SHOWING DENDRITIC WHORLS.

This micrograph shows a dendritic segregation of graphite. This formation is indirectly due to the crystallisation of prima austentite. It therefore denotes an iron rather low in total carbon. If the dendrites are small and the graphite flakes fine, the iron has been rather quickly cooled and is low in carbon. Such an iron is fairly high in strength, notwithstanding its uneven structure. If the dendrites are large and the flakes coarse the metal will be medium or low in strength. Tensile 38,070 x 75, unetched.

* The writer has explained his theory of this in "Foundry," September 1, 1923.

† Subtracting graphite from total carbon.

Brinell and Transverse.

Fig. 9 is a curve showing relation between Brinell hardness and transverse strength.* The bars at the lower end of the curve are from centres of 4 to 8 in. diameter bars. From 3,800 up the Brinell seems to increase more slowly with increase in strength. The Brinell follows the amount of combined carbon as seen by the microscope. For ferritic irons, with no combined carbon it is about 100, the Brinell of ferrite. It is 200 for the eutectoid irons, the Brinell for pearlite.

Effects of Structure.

There are two conceptions of grey iron's structure and related physical properties. One is that grey iron is, structionally speaking, steel with enmeshed graphite flakes. The strength of the metal increases up to 0.70 to 1.00 combined carbon

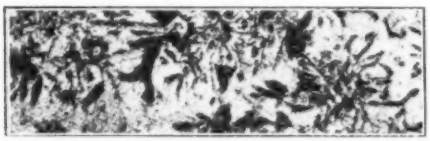


Fig. 11.—Structure showing Dendritic Whorls.

Fig. 11.—The whorl formation shown is commonly found in A. S. T. M. bars rather high in total carbon. It is the author's experience that such whorls come from ledeburite groups. Such bars may have these groups in very fine formations and be fairly strong. However, if there has been time for growths, the strength is much lower. x 75, unetched.

(the eutectoid matrix) just as steel increases in strength from low carbon to 0.90 carbon stock (not heat treated). The other conception is that the amount and size of graphite flakes is the major factor governing the physical properties. It is the writer's experience that the amount, size and distribution of graphite flakes is the best practical structural indicator of physical properties. On the other hand, the amount of pearlite, combined carbon structure, must always be considered.

The metal usually fractures along the planes of the graphite flakes. The size and distribution of graphite flakes determine the nature of the fracture and the grain of the iron.

The writer has found that size and amount *alone* do not tell the whole story, especially on the A. S. T. M. bar. In this bar the cooling conditions are such that the flakes have little chance for

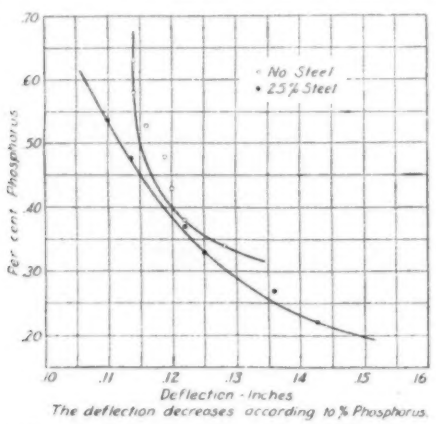


Fig. 11a.—Curves showing Relation Per Cent. Phosphorus to Deflection.

growth after their primary formation, and the matrix is nearly eutectoid.

Very uniform distribution promotes great strength, although the average size of flake may not be the smallest. This is well shown in a sample showing great transverse strength and very uniform structure.

The majority of high strength bars have very fine graphite, some of it occurring in dendritic formations. (Fig. 10.)

* The Brinell numbers were determined on an American model Brinell hardness tester, using microscope instead of depth gauge and 3,000 K.G. load.

Lower test bars often show whorl formations, as shown in Fig. 11. These whorls in the A. S. T. M. bar are largely a primary formation. The flakes are coarser and bunched.

Very large flakes indicate slow cooling and are not found in regular A. S. T. M. bars. These are accompanied by low pearlite.

Conclusions.

Graphite distribution is an important factor in determining the strength of the A. S. T. M. bar. Size, amount and distribution are factors which are very intimately linked. Distribution is most easily judged under the microscope and is the most significant structural detail of the A. S. T. M. bar.

Study of distribution must be done at low power magnification so that a representative area can be shown. Most high test irons show dendritic segregations, while low test irons have whorl formations. If all A. S. T. M. bars were cast at the same temperature* into moulds of equal heat conductivity, the most important variable would be the composition. In this case the analysis would tell the whole story, i.e., it would determine the variations in structure and physical properties.

Figs. 12 and 13 show Dendrites in Round and Square Bars.

The microscope is of value in that it will indicate abnormalities in cooling rate. The greatest field for the miscroscope is in examination of irons whose cooling rate is not known, and in research work.

TECHNICAL SUPPLEMENT.

Microscopic Methods.

Study of the composition and structure of the A. S. T. M. bar is complicated by the fact that the material is subject to considerable segregation. This is not always apparent in the ordinary analytical and microscopic tests, but is evident on macroscopic examination. For this reason it is necessary to study the macrostructure. Macrostructure is the structure apparent to the eye or on low magnification. Cast iron freezes selectively. As a result of this, there are segregations of graphitic carbon as shown in Fig. 10. These, of course, have considerable influence on the strength. Macroscopic methods also reveal the distribution of the phosphorus network.

Section Examined.

In ordinary macroscopic and microscopic tests on the A. S. T. M. bar the natural tendency is to examine a section vertical to the axis of the bar. This, in the author's experience, is the best method. The bar cools from the outside toward the centre. The primary crystals are arranged in

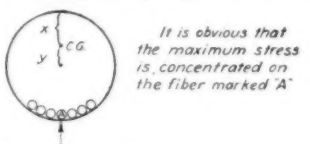


Fig. 14.—Fibres in Round Bars.

a sort of wheel formation. The influence of cooling from outside to centre can be seen very nicely on any part of the bar from 2 in. from the bottom to about 4 in. from the top. On the other hand, the structure on a section parallel to the axis of the bar will vary somewhat according to its depth. It is like cutting a chord through the wagon wheel —the ends of the spokes are seen, and certainly as good an idea of the wheel is not obtained as when viewing the whole wheel from the side. There is apparently little difference in samples with evenly distributed graphite.

Primary and Secondary Graphite.

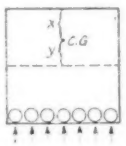
Graphitization is a continuous process. It is simpler, however, to consider it as taking place in

* The writer is talking about variables whose effects are fairly well known. The question of oxidation, of special virtue of certain brands of coke, pig, etc., are in the more theoretical stages.

two stages: (1) Primary graphitization of the cementite forms; (2) Secondary graphitization, the grain growth of graphite following its primary formation. This conception is justified by experimental evidence. The author has shown that the first formed graphite follows the outlines of the cementite formations. While these primary groups do not completely lose their identity, their graphite flakes grow and rearrange themselves. Due to the relatively rapid cooling of the A. S. T. M. bar, there is little time for secondary graphitization. The primary graphitization depends largely upon the analysis and the rate of cooling through the range that cementite separates.

Other Elements.

In the first parts of this article the author gave in detail results showing effects of variations in



In the square bar the maximum fiber stress is not concentrated on one fiber, but is resisted by all the fibers along the surface.

FIG. 15.—FIBRES IN SQUARE BARS.

silicon and the various carbon forms. There are three other elements commonly found in cast iron, namely, manganese, sulphur and phosphorus. As explained above, variation in these elements probably had very little effect on the curves given. Foundrymen have heard a great deal about the effects of sulphur, and the sulphur manganese ratio. In the ranges 0.07 to 0.15 sulphur and 0.35 to 0.80 manganese, the author has not observed any marked effects, bad or good traceable to these elements. Medium sulphur (0.10 to 0.15) tends to close the grain in heavy sections, which is a well-known fact. Sulphur used to be blamed for most blowholes, probably because the blowholes, seeking the top, occur on the cope side, and the sulphides, being light, float to the top, too.

Sulphur certainly does not form weak networks in ordinary irons. Manganese and the manganese-sulphur ratio in the ranges indicated do not seem to have much to do with most of the engineering properties of the iron. Of course, very low manganese metal from higher manganese irons indicates oxidation, as does excessive silicon loss, high iron slag, etc. High manganese is well known to increase the combined carbon.

Phosphorus is usually considered a promoter of fluidity, and many looked with disfavour upon the low-phosphorus irons. In the ranges from 0.20 to 0.80 phosphorus, the writer has observed little difference in the foundry. Temperature is the biggest factor in fluidity. Many who formerly used medium high-phosphorus iron pour low-phosphorus iron into thin sections with success. On the other hand, phosphorus is a hardener, not

The whole section does not cool at the same rate. For example, the outside (1) may be solid while the inner portion (5) is still liquid. Since cooling rate has a marked effect on the properties of the iron, the inner portion (5) will actually be a different sort of iron than the outside (1). This shows up in the strength, the grain size, the hardness, and in all the other engineering properties of grey iron.

FIG. 16.—CONCENTRIC COOLING.

necessarily apparent in a test like the Brinell test, but it is an abrasive hardener.

The most pronounced effect of phosphorus on the A. S. T. M. bar is its effect on deflections, as shown in the diagram, Fig. 11A. It apparently does not have much influence on strength.

Structure and Shape of Bar.

The crystallization of cast iron starts on the outside of the casting and runs toward the centre. (Figs. 12 and 13.) In a transverse test on any round bar comparatively few " fibres " receive the maximum stress. (Figs. 14 and 15.) On a square bar, however, there are a number of " fibres " which receive the stress at the same time, hence the square bar will resist a transverse test better. Engineers take this fact into account in formulæ for section moduli. The 1.25 in. dia. bar of the A. S. T. M. standard is 1.227 sq. in. in area and 3.927 in. in circumferences. A square bar the same area (1.227 sq. in.) as the A. S. T. M. bar has sides 1.108 ins., and a periphery of 4.432 ins. Therefore, area for area the square bar has two advantages. First, because of its greater periphery, cooling takes place over greater area. More rapid cooling results in smaller grain and greater strength if there is not too much chilling. Second, the section modulus favors the square bar, assuming that the material is homogeneous and in other

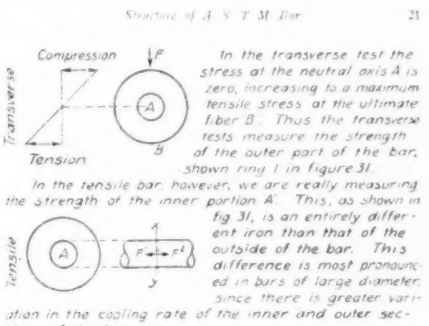

Structure of A. S. T. M. Bar
21
Compression
F
Transverse
A
Tension
B
In the transverse test the stress at the neutral axis A is zero, increasing to a maximum tensile stress at the ultimate fiber B. Thus the transverse tests measure the strength of the outer part of the bar, shown ring 1 in figure 31.
In the tensile bar, however, we are really measuring the strength of the inner portion A. This, as shown in fig 31, is an entirely different iron than that of the outside of the bar. This difference is most pronounced in bars of large diameter, since there is greater variation in the cooling rate of the inner and outer sections of the bar.
Tensile
A
F
F
y

FIG. 17.—STRESSES IN TRANSVERSE AND TENSILE TESTS.

ways conforms to the requirements for application of the formula.

$$\frac{X^3}{6} = \frac{1.108^3}{6} = 0.226 \text{ (square bar)}$$

$$\frac{A}{4}r = \frac{1.227 \times 0.625}{4} = 0.192 \text{ (round bar)}$$

These differences are apparent in actual practice. Cast iron does not come up to all the requirements for application of the section modulus law. The flat surfaces are rarely truly parallel and straight, the knife edges rarely are in exact alignment, the material is not homogeneous, etc.

Due to structures formed in cooling, the round bar is more uniform than the square. Sharp corners are always sources of weak structures. This is seen in heat treating, in ingot making, in casting practice and in all places where metals are cast or fabricated. The round bar also seems to be the one giving the most accurate measure of the ultimate fibre stress—the property of cast iron

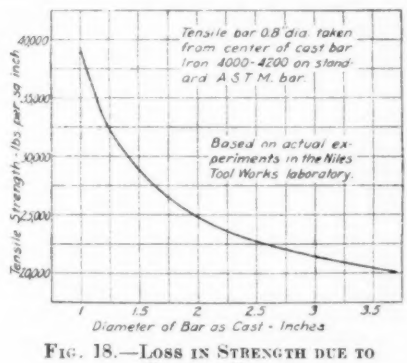


FIG. 18.—LOSS IN STRENGTH DUE TO SECTION SIZE.

which is really of most interest to engineers. For these reasons the writer is inclined to favour the round bar for testing work.

Transverse and Tensile.

Castings rarely break due to true tension stresses. The usual stresses are of the cantilever type. Nevertheless, nearly all engineering formulæ use tensile strength. Most tests of cast iron are transverse. The difficulty of getting proper results from the tensile strength are well known. All ratios of tensile to transverse are arbitrary. There is no logical connection, as two different irons are being tested. Fig. 16 shows how the physical properties change gradually from the outside to the centre. In the transverse test it is the stronger outer " fibres " which are stressed. In

the tensile test, the weaker centre structure is stressed. The diagram, Fig. 17, illustrates these stresses. In smaller bars the cooling is more uniform and the differences are not so extreme between the outer and inner portions. In a very large bar the outside may be fairly strong and the inner portion very weak. The A. S. T. M. bar is large enough so that many irons show considerable difference between their outer and inner structure.

Size of Test Bar.

The standard A. S. T. M. test calls for a 1.25 in. dia. bar. The author has at hand a considerable amount of data on the 1, 1 1-8, 1 3-8 and 2-in. sizes. The smaller bars undoubtedly have better structure, provided silicon is high enough to avoid excessive chilling. This difference is very apparent in the tensile test. Iron giving a bar of 4,000 pounds standard transverse test will give about 40,000 pounds tensile if cast into 1-in. bars. The tensile test is sensitive even to the slightest variations in section size. A 1-in. bar which gives, say 17.8 tons tensile will give 14.7 to 16.0 in the 1¼-in. dia. bar, about 13.3 to 14.2 in the 1 3-8-in. dia. bar and 10.7 to 11.6 in a 2-in. bar. This is assuming, of course, that the tensile test bars are of the standard dimensions, cut out of the centres of the respective bars. A 4,000 lb. standard transverse bar is approximately equivalent to a 16,000 lb. 2-in. dia. transverse bar. The respective areas are 1.227 and 3.142 sq. ins. (radii 0.625 and 1 in.). Section moduli

$$\frac{Ar}{4} \text{ or } \frac{\pi r^3}{4} \text{ in the ratio :}$$

$$\frac{(0.625)^3}{1^3} = \frac{0.244}{1} \text{ or about 1 to 4}$$

This is the same ratio as the actual tests. Therefore, to get results of good appearance, it is best to make small tensile bars and large transverse bars. It is obvious that transverse tests cannot be converted area for area, as is sometimes done.

The writer has at hand analytical summaries for about 300 1 3-8-in. dia. bars and 125 2-in. bars. The results, from a qualitative viewpoint, are similar to those given in this paper. However, the slower cooling rate has its effect and the bars seem more sensitive to changes in pouring temperature. In bars 4 ins. to 8 ins. dia., the pouring temperatures have a very great influence indeed!

What test bar is most practical? The author feels that until a very great deal more research data is available it is best to stick to the present standard bar. Smaller bars do not seem to show the effects of the elements as well. Larger bars depend more on pouring temperature. *Research and practical experience determine the relation* of the bars to the castings. Placing a coupon on the casting and other subterfuges are rarely satisfactory.

DISCUSSION.

Mr. John Shaw (Sheffield) writes :—

Mr. Bolton's work always commands thought and can generally be perused with profit. In the present instance, however, while a good deal of work has been put into the paper, so little definite information has been given that the figures given are of little value. In Fig. 1 no total carbon or other constituents are stated. That silicon up to a point opens the structure of an iron by its action on the total carbon has been known for the last 40 years. Its decreasing influence with lower total carbon present is not as well understood. For instance, recently on a down gate 1¼ in. dia. from a semi-steel casting, the silicon was 3.06 per cent. with the total C 2.98 per cent. The tensile from this gate turned down to 0.8 in. in the centre gave over 18 tons per sq. in.

Tables II, III, IV and V.

Here again one cannot make any comparison with British practice. One can only surmise that there is at the starting point of each graph 1.10 per cent. silicon, with 3.05 per cent. C, climbing up with an increase of both Si and C to 2.3 per cent. Si and 3.65 per cent. C. How is it possible to arrive at any conclusions when neither of the main constituents are stationary?

With most of the general conclusions I agree. Several do not coincide with my experience. I have given an instance where increase of Si when not considered in conjunction with lower total carbon does not show a lower strength. I agree that after a certain point, increase of either Si or T.C. decreases the strength, but it does not follow that the sum of the two will always give even approximately the same strength, even when the conditions and other constituents are the same.

There is no doubt steel additions give a more finely divided graphitic carbon. This, together with the difference in analysis, accounts for the increased strength. Whether this is due to oxygen or other gases, as recent German work would tend to show, is an open question.

Referring to Figs. 6, 7 and 8, there are two fundamental facts stated that govern the whole test bar question, viz. : " That increase in CC increases the strength to a maximum at 0.7 to 1.00 per cent., from which point the *strength falls off very rapidly*. Decrease in CC results in decrease of strength to a minimum."

That means in nearly all Diesel liners, liners for large marine or land engines, hydraulic cylinders, to mention only three types of castings, the arbitration bar would contain about 2 per cent. CC if suitable metal was used, therefore a reduced load on the arbitration bar and not an increase as in the present A.F.A. Specification.

Again referring to Figs. 6, 7 and 8, there is no means of arriving at the T.C. of any tests. One may by taking the highest test of 5,600 lbs. arrive at a figure of (2.38 per cent. plus 0.7 per cent.) 3.15 per cent. T.C. That test is represented quite low in Fig. 8. In short, how any conclusions can be drawn, except by those who are in possession of the whole facts, I fail to see. Mr. Bolton's statement that " The primary distribution of graphite is very important " is one reason why irons with the same G, C and CC fail to give the same test, other conditions being equal.

I agree that the transverse is the most suitable test for cast iron. If the breaking load was also stated in terms of the " Modulus of Rupture," engineers would find it quite convenient. With his conception that the amount and size of the graphite flakes is the major factor governing the physical properties, when coupled with his later statement, I am in agreement, but he does not tell us how he obtains this control. Seeing the structure under a microscope may show where the weakness is, but does not state the remedy.

Part IV.—If Mr. Bolton has not observed any marked effects from S or Mn, either good or bad, perhaps he will tell us why a mixture containing 0.07 per cent. S and 0.8 per cent. Mn that shows a chill of 1⅞ in. on a rapid chill test will only show ¾ in. on the roll from this metal, while an iron containing 0.15 per cent. S and 0.3 per cent. Mn showing 1⅞ in. chill on the rapid test will show 1⅝ in. on the roll, no appreciable loss of either S or Mn being observed when both the rapid tests and turnings from the rolls were analysed. After all, a chill test is the best test of structure. These variations are used purposely to obtain certain definite properties.

We find that influence of P extends to the transverse test as well as the deflection, but does not affect the tensile test.

Coming now to the final point. In view of his previous conclusions, I am utterly at a loss to understand his attitude with regard to the size of bar. It would seem to obtain a strong test bar is of more importance than a strong casting. He shows clearly that an iron that will give 40,000 lbs. on an inch dia. bar falls to 25,000 lbs. on a 2-in. bar reduced to 0.8 in. in the centre if cast from the metal suitable for 1 in. thick castings. If he will use a metal suitable for a 2-in. casting and over for his two bars, turning his 2-in. bar down to 1.785 in. in the centre he will find his results reversed, as he himself proves earlier on in the paper. If a casting has to be 2 in. average thickness or over, then it is best to make the bar about the same section as the casting, so that at all events if cast at the same temperature and conditions, some idea of the metal going into the casting will be obtained. There are sufficient snags without making any.

MR. J. HARLEY, founder of the Fife Forge Company, Limited, died recently at his residence at Blinkbonny, Kirkcaldy, at the age of 88.

Institute of British Foundrymen.

SCOTTISH BRANCH.

The first meeting for the current session of the Scottish Branch of the Institute of British Foundrymen was held in Glasgow, when Mr. James Affleck, B.Sc., delivered his presidential address. There was a large number of members and others present.

At the commencement of the proceedings Mr. John Bell, Hon. Secretary, intimated that arrangements were being made for the next Convention of the Institute which would be held in Glasgow in June of next year. At the last Convention, Mr. Bell said, Mr. John Cameron, of the Scottish Branch, had been elected senior Vice-President, and in due course he would occupy the Presidential chair. As it was usual to hold the Convention of the Institute in the territory of the President-designate, that event would take place in Glasgow. Already preliminary arrangements were being made and an influential committee had been appointed. Included in its membership were Lord Weir, Lord Invernairn, and Mr. Pate, of Falkirk. The dates fixed provisionally for the Convention were June 10, 11 and 12.

PRESIDENTIAL ADDRESS.

Mr. Affleck then delivered his presidential address as follows:—

In looking over the list of my predecessors in the honourable position of President of the Scottish Branch of our Institute, I find the names of many distinguished foundrymen, names which are more or less household words in the foundry trade. You will, therefore, readily appreciate that I accepted the position with some degree of trepidation. At the same time I think I may safely say that although all my predecessors may surpass me in talent and abilities, I am quite certain that none will exceed me in gratitude and appreciation of the honour you have done me in electing me to this chair, and I assure you that my very best efforts will be devoted to the interests and the prosperity of our Institution.

In an Association such as ours, in which the membership is composed of iron, brass and steel founders, it is, I think, desirable that the subject of a presidential address should be of general rather than of purely technical interest, and with this in view I propose to place before you a few thoughts on one or two subjects which influence, more or less, all branches of foundry activity.

Suggested Improvement.

Mr. Henry Ford, the celebrated American motor manufacturer, in his recent book describing his life and work, says, in speaking generally of the development of industry: "The progress has been wonderful enough, but when we compare what we have done with what there is to do, then our past accomplishments are as nothing." While I cannot help feeling that Mr. Ford's modesty regarding his own accomplishments is perhaps excessive, and certainly most unusual in an American manufacturer, I am certain that what he says is profoundly true of the foundry industry to-day. We all feel that a vast and ever-growing field lies before us, and that great advances in foundry technology and in foundry practice will be made, and, in fact, must be made, to meet the demands of allied industries. It is my purpose this afternoon to indicate briefly one or two of the factors which may influence progress, one or two avenues along which suggestions for improvement might be made.

Effect of Cheap Power in Foundry Developments.

It is unfortunately the case that the commercial conditions in most branches of the foundry industry at the present time, although improving, are still very unsatisfactory. Costs are high, prices are low and extremely competitive. In very few businesses is the margin of profit sufficiently great to enable the management to even consider any serious scheme of improvement or re-organisation. In this respect I do not think I am far wrong in saying that 90 per cent. of British foundries have during the last few years been absolutely marking time as regards serious expenditure on development work. At the same time I am quite certain that British foundrymen in general, and Scottish foundrymen in particular, have not by any means been asleep, and that many of them have, by an intensive study of their present plant and processes, effected most striking economies in production, and more or less prepared themsedves for that wonderful boom in trade which has been so long foretold, but which, like Royal Charlie, is very long in coming.

How Railway Electrification Would Help.

Looking over the industrial field of Great Britain from the broadest point of view, we find there are one or two national questions in which the foundry industry, along with other industries, is specially concerned. Perhaps the most important is that of the supply of cheap power, particularly in the form of electric energy. Certain schemes are now afoot, supported by national funds, for the supply of electricity in bulk to various districts. In some cases the source of energy is found by the harnessing of water power, in others by the unification of existing electric supply schemes. Severe pressure is also being exerted on the railway companies to electrify their systems, and, if this were carried out, as it may be in the not too distant future, it would, in my opinion, produce an almost revolutionary effect on industry. The electrification of the railways would mean that electric cables and an electricity supply would be carried with the railways into every corner of the country. Uniform load conditions, the lack of which is now the bugbear of all electric supply schemes, would be secured by the continuous railway traffic, and a large surplus supply at cheap rates could be arranged for industrial purposes.

Brass Foundries and Electric Melting.

These schemes no doubt seem far removed from the everyday interests of foundrymen, but I think, nevertheless, that they deserve more than passing attention on account of the important developments they may bring in their train. I refer particularly to the possibility, if a cheap supply of power were available, of the greatly extended use of electricity in foundry practice, particularly for melting operations. At the present stage of development, if really cheap electric power were available, the greatest benefits would probably be gained in steel and brass foundries, and would be associated with the use of electric furnaces. The great advantages resulting from the use of electricity in steel melting generally, and particularly in the manufacture of special alloy steels, have been generally recognised, but I do not think the corresponding advantages and possibilities of this method have been appreciated to the same extent by brass and iron founders.

In many brass foundries, even very large foundries, the melting methods are still in the mediæval stage, and the ordinary pot furnace reigns supreme. There is no doubt that, where

small heats are the rule and where a number of different mixtures are in use, this type of furnace offers distinct advantages, but where comparatively large amounts of metal are required, the foundry conditions become very arduous, unhealthy and uneconomical. In more modern foundries, where a considerable amount of non-ferrous metal is melted, the pot furnace has been superseded by the crucible tilting furnace and the air furnace, but to my mind the ideal is certainly the electric furnace. This is particularly the case where brasses of high zinc content are being handled, and where, consequently, the metal losses by oxidation and volatilisation using the ordinary methods of melting would tend to be very high. With a good type of electric furnace these losses may be kept very low indeed. Further advantages are high-quality metal and very accurate temperature control. Labour charges are also considerably less, there is no fuel to charge and no ashes to cart away. Last, but not least, the atmosphere, working and other conditions affecting the health, comfort and safety of the worker are greatly improved. From the financial point of view also, an important aspect in these hard times, the balance-sheet compares favourably with that of other types of furnace, providing one condition is favourable, namely, the cost of electric energy. A cheap supply of electricity would no doubt lead to the wide adoption of electric furnaces in this country, as in the U.S.A., where some foundries have as many as 80 electric furnaces installed under one roof.

Cupola *v.* Electric Furnace.

But while the most favourable sphere of operation of electric furnaces would appear to be meantime in brass and steel work, there is also a certain field even in iron foundry work, and this field is gradually extending. The great god of the iron foundry meantime is, of course, the cupola, and the cupola is undoubtedly a wonderful tool, which, in the hands of experienced foundrymen, gives results of marvellous consistency. For certain classes of work, and particularly for very heavy work, it is doubtful if the cupola will ever be superseded by any type of furnace. It is well, however, in dealing with the possibility of evolutionary changes in furnace or melting practice to look at the matter as far as possible from the broadest point of view. The function of the foundry industry is to supply the demands of the engineering and other industries as regards castings, and accordingly it naturally follows that the foundry industry must react to and may be vitally affected by technical developments of all kinds in other industries. Generally speaking, the present-day tendency in machinery is to reduce weight to a minimum. This, of course, implies stronger and superior material to closer specification and analysis. There is a great and growing field for irons of very special quality. The Diesel engine industry, for example, which is developing with extraordinary rapidity, demands irons of characteristic properties and strength, and, as the weight of Diesel engines per horse-power at the present time is extremely high, there is not the slightest doubt that Diesel engineers, in the near future, will be demanding still stronger irons with a view to reduction of weight. In steam engineering, also, the tendency is to use higher and higher steam pressures, and plants are now being designed to operate at steam pressures as high as 1,200 lbs. per sq. in. These pressures are associated with very high steam temperatures and demand very special metals. In fact, in all branches of mechanical industry the demand is insistent for stronger and more reliable materials carefully selected and specially adapted for the particular work they may have to perform, and foundrymen must be prepared to anticipate these demands and to adapt their organisations and resources to meet them. How far and for how long the cupola will be able to meet the growing demands for irons of very special quality remains yet to be seen, but, meantime, if electric supply conditions are favourable, the electric furnace is certainly capable of acting as an efficient adjunct and possibly as an ultimate successor to the cupola. The easy control, accurate temperature regulation and synthetic building up of accurate compositions which are possible with electric melting, not to mention other incidental advantages, such as speed in melting and improved labour conditions, should make the proposition attractive to most foundrymen. Here again, however, it appears to me that the controlling factor must ultimately be the cost of electricity in bulk supply, which will depend to a great extent on the successful development of these national schemes for power distribution to which I have already referred.

Technical Status of the Industry.

There is another matter of general interest to which I may, I think, fittingly refer on this occasion, and that is the present technical status of the foundry industry. There is a suspicion abroad at the present time that, technically speaking, all is not well with the foundry trade in this country. Considerable discussion has taken place over the action of one or two prominent firms engaged in large diesel work who have recently ordered iron castings from foreign firms without even offering the work in the home market. While these firms may have the best of reasons, from certain points of view, for this procedure, it appears to me, from the broad standpoint, to be rather a short-sighted policy. It is certainly very discouraging to British foundrymen, and shows an alarming lack of confidence in the ability of the home industry to successfully handle new problems and conditions, a lack of confidence which I think is hardly justified by the past record of British iron-founding. The question then arises—is this lack of confidence justified by present day conditions? I cannot speak from personal knowledge in this case, but in the arena of commercial life one sometimes strikes against hard and disturbing facts, and I might mention a recent personal experience in another sphere of foundry practice of rather a disquieting character. The castings required were of steel, and weighed in the rough about 15 cwts. The job was undoubtedly a difficult one, as the structure of the castings was somewhat complicated, and the designed metal thickness only $\frac{5}{8}$ in., lightness being of great importance in the particular machines in view. Patterns of the highest class were provided, and these castings were offered to various steel founders throughout this country, also to certain continental firms of repute. While on the one hand the foreigners all readily offered for the job, quoted reasonable prices, and displayed eagerness to get the work, on the other hand the greater number of the British firms who were approached simply declined to undertake the work; a few quoted conditionally on the thickness of the casting being doubled; and one or two, who obviously did not want the job, quoted absurdly high prices. The procuring of these castings became a source of worry and anxiety to all concerned, and for some time it appeared as if it would be necessary to place the order abroad. It is incidents like this which tend to shake the confidence of clients in the home market, and raise doubts as to the technical resources of the home firms. Many steel foundries have possibly not the equipment for work of this nature, as I am convinced that electric steel is necessary to make a really first-class job of castings of this kind, but the whole circumstances do not reflect much credit on the steel casting industry generally in this country, and show, or at least appear to show, a striking lack of that ability, courage, and enterprise which we usually associate with British manufacturers. I am happy to say that the problem was finally tackled, and looks like being solved, by a Scottish firm not 100 miles from Glasgow. There is little doubt that in the next few years we shall be called upon to face the severe competition, in the world's markets, of Germany, not militarist Germany, but "deep-thinking, patient, laborious Germany," and possibly, before very long, the competition also of powerful Franco-German combinations with immense resources in plant and finance. Some people may regard this as a misfortune, but it seems to me that it may prove a blessing in disguise, as it may awake us from our apathy and evolve that inherent characteristic of our race, that "dourness" which has carried us over so many obstacles in the past. Character alone, however, will not

carry us through difficulties of this nature; we must take advantage of all the means of grace in foundry technique. Signs are not wanting that important advances in foundry practice which have only been partially disclosed, have taken place on the Continent, and if our commercial success is to be assured, it is incumbent on every progressive foundryman to take stock of, and to overhaul his equipment from both the mechanical and scientific points of view.

If foundry practice is considered from the standpoint of an art or handicraft, I believe that British foundrymen can defy the world, but I have grave doubts as to our position with regard to mechanical equipment and scientific methods, particularly the latter. A great deal has been spoken and written about the place of science in the foundry, and for years the technical press has been deluged with a roaring cataract of articles, mainly on metallurgical science. Many of these articles have been of great interest and importance, but a large number of them I would venture to say, deal with abstruse and research aspects of metallurgy which have little interest to the average foundryman simply because he sees no way of making any practical use of the information given.

The Gulf between Theory and Practice.

The skilled chemist and metallurgist may place before the foundrymen the most minute details regarding the micro-structure of any given metal. He may define very concisely its physical and chemical constitution and characteristics; he may state its properties under varying temperatures or other conditions, but he may be still very far from making any serious addition to actual foundry knowledge of the metal, any addition to that information which the foundryman requires to enable him to make a sound casting corresponding to the metal described. No person interested in foundry practice can read the technical literature associated with foundry work without feeling how singularly ineffective some of it is in respect of the enlightenment or solution of some of the most serious foundry problems. To the foundryman, a great many of, I might say the bulk of current scientific articles, and I am afraid even some of our Institution lectures, appear to be of the treadmill variety, and so far as practical work is concerned, to end where they begin. From the nature of current scientific literature it would appear that many of our metallurgists appear to have no desire for the serious study and attack of some of the most obvious every day problems of the foundry, they evidently prefer to patrol the high grounds of research. From certain points of view, of course, their attitude may be completely justified. From the other point of view many foundrymen find themselves separated from the developments of metallurgical science by a wall of more or less obscure technicalities which they have neither the time nor the inclination to surmount. The ideal condition, as expressed by the motto of our Institute, "Science hand in hand with labour," seems still to be far removed from the realities of work-a-day life. I feel strongly that this gulf which exists between theory and practice is a reality and must be bridged in some way before our industry is on a proper basis. The inherent reason lies, of course, on the one hand, in the comparative inexperience of many scientific workers of foundry processes, problems, and difficulties, and on the other hand, in the inability of many foundry workers to appreciate and give practical application to scientific facts and principles; the remedy seems to be that the scientist must become more of a foundryman, and the foundryman more of a scientist. It is my experience that when hard scientific facts are available in the proper form, no class of man is more enthusiastic in applying them to practical work than the foundryman. As an illustration of this, I might refer to one of the most interesting examples of practical technical instruction in foundry matters, namely, the "McLain" system as developed in the U.S.A. As applied to the manufacture of semi-steel in the cupola, this system has been studied and successfully operated all over the world, and McLain graduates are to be found in all countries. It is a combination of technical and practical information such as I have already referred to, and in such a form that it can be directly applied to industry. Investigation of the actual system seems to show that, so far as the theoretical part of the instruction is concerned, the information given is not new; the facts and principles enunciated have been well known to metallurgists for years; the success of the system is due to the practical application of these facts and principles. The information given is such as to enable the practical man successfully to run semi-steel and, so far as the foundryman is concerned, this appears to me to be the vital matter. I may say I hold no brief for the McLain system; I have never been a student of the system; I merely mention it as an illustration of the power and interest of applied as distinct from purely academic science.

As a further illustration of what I mean, I might mention the technical position regarding that material which is now exciting interest in foundry circles, namely, the so-called pearlitic cast iron. This material, which is being put forward to replace cast steel and malleable cast iron, is a low silicon, low carbon iron of great strength, and is reputed to show minimum growth under repeated heating and cooling. When cast at the correct temperature into a heated mould, also at the correct temperature, the metal requires no feeding heads, due probably to its short freezing range, and the casting may be readily machined and worked. The properties of the material are, in fact, such as to excite the envy and curiosity of all ironfounders, particularly those engaged on special work. If cast in the ordinary way, however, the normal impracticable white iron structure would be produced. The constitution and structure of so-called pearlitic cast iron are well known to metallurgists, and can undoubtedly be reproduced under laboratory conditions, but when we enter the realm of the commercial production of castings, the problem becomes much more acute. When the ironfounder sets out to make a casting of this material, who can tell him what should be the exact composition and temperature of the mould, or parts of the mould, to give the required structure and properties? This is the vital information for the founder, and constitutes one of these problems in applied as distinct from pure science, which, in my opinion, can only be solved by the active co-operation of the scientist and the practical man.

The Value of the Research Worker.

But while the immediate concern of the foundryman lies in practical applications or applied science, we must not fail to appreciate the great importance of research along the line of what is usually termed pure science. The worker in pure science, the man who devotes himself to the intensive study of natural phenomena from pure love of the subject is, in my opinion, one of "the salt of the earth." He works in a realm far removed from that of ordinary commercial cupidity and hustle, a realm of "toil unsevered from tranquillity," and while his financial reward is often relatively very meagre, his value to the community is sometimes immeasurably great. In fact, some of the most important industrial developments of modern times have been the outcome of the work of men of this class. It is rarely that the results of their labour become immediately absorbed into practical affairs. The records of their work may slumber for years on the dusty shelves of laboratories, but in the course of time very often simple researches have far-reaching results in industrial life. Who can estimate the profound effect on the iron and steel industry of the pioneer work of men like Turner, Stead and other research workers? In another sphere, that of electrical engineering, we find that about 18 years ago Mr. W. Dunwoody discovered experimentally that a carborundum crystal or silicon carbide possessed the property of transmitting oscillatory electric currents more easily in one direction than the other. Further research then showed this property to be more or less common to all crystals. Who could have predicted that this obscure research, and the discovery of this peculiar property, would to-day make possible by the simplest and cheapest means the wireless reception of entertainment and instruction by millions of people, that it would lead to the foundation of a great new industry, that it may ulti-

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mately be utilised to enable the voice of a single human being to be heard all over the world.

It is gratifying to note that the great importance of iron foundry research has been recognised in this country, and has led to the formation of the British Cast Iron Research Association. This Association, which is assisted in a moderate degree by public funds, is designed to effect, as far as possible, that co-operation between pure and applied science which is of such vital importance in industry. The Association now possesses a scientific laboratory for experimental research, and arrangements have also been made for extensive experiments on a commercial scale in the works of certain of its members. During its comparatively short life most important practical results have already been obtained and communicated to its members. Other researches on outstanding problems are now in progress. In spite of this somewhat extraordinary record, it is a remarkable fact that the great possibilities and value of an Institution of this kind in solving industrial problems do not appear to have been realised by the majority of ironfounders in this country, as the percentage who have actively interested themselves in the Association is relatively small. It is difficult to account for this appalling apathy in the face of modern conditions and foreign competition, although financial stress is at the root of some of it, and it is to be sincerely hoped that before long the greater number of the ironfounders will have realised their responsibilities and extended their support to the scheme. For commercial success we dare not leave any stone unturned in our efforts to bridge the gulf between science and practice, we dare not spare any effort to obtain for foundry work wherever possible that mechanical precision and accurate control of process which makes for the highest efficiency. Membership of the Research Association is one of the most direct means to this end, and the united labours of scientists and practical men provide in the Association a reservoir of important information which is the business of the Association to transmit to its members.

The Education of the Worker.

But there is another important element in foundry work which must not be neglected, and that is the human element. Some of us are convinced by experience that this is perhaps the most important element of all. Although the use of machinery is gradually extending in foundry practice, particularly in repetition work, the industry as a whole is still very far from the purely mechanical stage—founding is still an art requiring very special qualities of knowledge, initiative and practical skill, qualities which depend to a very large degree on the experience and training of the workers of all grades in the industry. This brings us to what one might call the "hardy annual" of presidential addresses, the subject of the education of foundrymen. A great deal has been written on this subject, particularly on the education of apprentices, and many elaborate schemes and syllabuses have been put forward. The scheme recently adopted by the French Foundry Employers' Association is extremely interesting, including as it does the direct tuition of apprentices in both practical and technical work, and opening as it does a direct path for apprentices to graduate from elementary classes in the foundries and evening schools to the Technical High School in Paris, where training may be obtained for the very highest positions in the industry. We have no co-ordinated scheme of this kind in action in this country whereby classes are carried on by employers, although the provisions of the new Scottish Education Act, when it comes into operation, will make the attendance of young employees compulsory on part time day continuation classes which may be of a technical nature. So far as I am aware, however, only one or two firms in Scotland have organised works classes for foundry apprentices in co-operation with the Education Authorities, and in anticipation of the Act and in the present depressed condition of the industry it is, I suppose, unreasonable to expect any general move in this direction. A number of firms, however, have appointed special men for training apprentices in practical work on the foundry floor as recommended in the French scheme. This scheme, although supported by Government funds, does not appear to be compulsory in any way, the initiative evidently being left in the hands of Local Associations of Employers. Generally, one cannot help gaining the unpleasant impression that, so far as the organisation of technical education for foundry workers is concerned, the Frenchmen have been more enterprising, and are distinctly in advance of this country. It appears to me, however, that, while organisation of this kind is of importance, the central and everlasting problem of foundry education, as of all kinds of education, is the problem of really awakening the interest of the person concerned in the subject of study. I have had some personal experience of this aspect of the problem in a foundry with which I was associated for some years, and in which classes in foundry subjects for apprentice moulders were carried on during working hours.

It was found that while many of the apprentices were keen, others were apparently entirely indifferent. A few were even actively hostile, and methods bordering on "Prussianism" had sometimes to be used to induce them to attend at the "seat of learning." In cases such as this, where interest in the subject of study is lacking, it is extremely doubtful if the youth really profits by the time spent in the class-room. Certainly I can sincerely sympathise with him in sitting out lectures on subjects which bore him to the backbone. No doubt he learns to look on the works school as another of the many discomforts associated with foundry work. The problem of interest is undoubtedly a difficult one. It is affected by factors over which the employer, manager, foreman, or teacher has little or no control—by factors such as physique, health, home life, natural aptitude, and most directly, by primary education. In this connection it appears to me that the far-reaching influence of the primary school teacher is not sufficiently recognised by those engaged in industrial work. He it is who handles the raw human material in its most plastic condition. He has at once the responsibility and the opportunity of implanting those ideals of public service, of fair dealing, of thoroughness, of pride in a good job for its own sake, which affect so profoundly the mental attitude of the boy towards his work, and which mean so much more than mere learning in the making of the master craftsman. If these ideals were instilled in the early stages of life, if boys were taught to respect and admire skill in handicraft as they now learn to admire skill in games, if work were presented to them, not as a penance, but as an interesting vocation, then I think the problem of the technical education of the boy for his selected trade would be moving towards solution. The actual course of instruction should, I think, even in the early stages, have a strong practical bias. In teaching simple scientific principles it is surely not difficult to obtain illuminating examples from the workshop itself. No attempt should be made, however, to make scientific experts of youths who wish only to be competent moulders or to cram them with facts having little or no bearing on their daily work. Those of us who have been through what I might call the "valley of the shadow" of modern education know only too well its weakness in this last respect. Great stress is laid nowadays by teachers, education authorities, and others on what they call cultural education. Its value cannot be denied, and it undoubtedly adds to the pleasures of life. But, after all, a knowledge of Latin prose composition or Greek poetry does not carry much weight in the iron foundry, and the education and training which enables a youth to earn his living and serve the community in an efficient manner must, after all, take first place. These matters are worthy, I think, of our serious attention, because I feel certain that, sooner or later, the foundry industry in this country will require to organise the education of its workers, young and old, and that we, as an institution and as individuals, will require to face and solve every aspect of the education problem.

The Importance of Educating the Adult.

And the problem of education does not end with the youths or adolescents, who are, after all, only

foundrymen in embryo. It extends also to the adults in the industry, to those foundry workers, often of ripe practical experience, who take, or appear to take, no interest in the technical side of their vocation. It seems to me that the field here is of equal importance, and the difficulties equally as great, as in the case of the youth. The youth in industry must always be an uncertain factor as regards his future possibilities and his career. In the case of the adult we are on surer ground, as he usually possesses in a large degree the vital practical experience and training which may be amplified and enriched by technical knowledge. The Prime Minister, Mr. Ramsay MacDonald, in a message to the Adult Education Conference, said recently:—

> "We are only beginning to understand the importance of adult education. Unless we keep our adults in contact with those influences which make mature minds, and keep them ripening into an ever richer fullness, our people will suffer from arrested development, and the education they get in their youth will be largely wasted."

No better justification for the existence of our Institute could, I think, be obtained than is contained in this statement. I think we must recognise it to be profoundly true, even in the more or less restricted sphere of technical education. Facilities for adult education are necessary not only to assist the present generation of foundrymen, but to ensure that our efforts for the rising generation will really bear fruit. In providing these facilities, our Institute must surely play a prominent part. The obstacles in the way of adult education are, of course, of the same general nature as in the education of apprentices, the main trouble being one of diffidence, and the most serious problem being the awakening of interest. If we can arouse one-tenth of the discussion and excitement over our Institution Papers and meetings as we find taking place week by week over the Scottish Football League Competition or in "spotting the winner," this room will hardly hold us, and our foundries will be speedily transformed. The awakening of this interest must depend very greatly on the keenness and enthusiasm of the members of our Institute, each one of whom goes forth as an ambassador to the foundry, to the laboratory, or to the pattern shop, which form our recruiting ground. On our personal efforts in these fields will depend our success or failure. By gaining in this way, as far as possible, the personal interest of every craftsman in the industry in our Institute, we shall take the most direct means of broadening its influence; we shall avoid the disaster which has befallen other societies like our own, of becoming merely a happy hunting ground for the managerial and employing classes; we shall take the most effective step towards increasing its power and prestige in the community.

The Attraction of the Foundry.

In closing what I feel has been a somewhat discursive address, I do not think I am exaggerating when I say that, although the environment and amenities of foundry work may not be comparable with some other branches of industry, although on occasion foundry work implies both difficulty and discomfort, it nevertheless offers a field and a career, particularly for young men, which is excelled by no branch of engineering or mechanical art. In the foundry, as in no other branch of the metal industry, men are confronted with the raw forces of nature, including, at times, human nature, in their crudest form. The conflict with these forces tends to develop the best type of character, as revealed in those qualities of courage, hardihood and skill often exhibited by moulders under the most trying conditions as part of their daily work. The present-day technical problems of the foundry are of such a nature also as to test the most acute brains and the most cunning handicraft. Fame and fortune wait on the solution of some of these problems. In fact, I know of no trade or profession which offers superior attractions in this respect, no field in which men of ability and enterprise have more scope. The fact that the founding of metals consists so largely of art and handicraft is, in my opinion, one of its chief attractions as contrasted with the more or less mechanical processes of other branches of the metal industry. During the Great War a distinguished author was commissioned by the British Government for propaganda work, and for this purpose toured the country inspecting engineering and munition works. During his visit to one of the large engineering establishments in this district he was conducted over the works by a personal friend of my own, who noticed that he showed unmistakable signs of acute boredom and exhibited only the most languid interest in machine-shop processes generally. In view of this, it occurred to the guide to take his visitor into the foundry. The effect was instantaneous. The man was transformed, and exhibited the most intense interest in every process to the extent that it became a matter of some difficulty to get him out of the foundry again. He had obviously never been in a foundry before, and expressed his delight and charm at the delicate processes and manual skill involved in the working of the sand. In spite of the dust, the smoke, and the grime of the foundry, kin drew to kin, and the true artist in literature was instinctively attracted by the work of the artist in sand. It is desirable, I think, for us not to lose sight of the artistic aspects of the craft, although these are very often obscured by the vile conditions under which work is carried on. Sentiment and enthusiasm are powerful influences in life, and sometimes transform the drudge into the willing worker. Mr. Rudyard Kipling, in his poem entitled "McAndrew's Hymn," depicts the emotions of an old Scotch sea-going chief engineer as he stands by his engines on watch at sea and listens to their rhythmic beat. His romantic vision endows the engine with life, and feeling his inability, as a mere practical man, to express his experiences and emotions, he exclaims in a moment of ecstasy, "Lord, send a man like Robbie Burns to sing the Song o' Steam." When we consider the life-long labour and enthusiastic devotion of some of the members of our Branch, past and present, in the interests of the craft, we cannot help feeling that they must have been inspired by similar sentiments, and, like McAndrew, have sighed for a poet to express their emotions and to sing the Song of the Foundry. It is a sad fact, however, that in far too many foundries at the present day the working conditions are such as to provoke not poetry, but profanity, and there is no doubt that these conditions must be swept away before the foundry industry can attain its rightful dignity and status in the community. Our ancient craft has been the handmaid of humanity from the dawn of history to the present day; the moulder has done as much for civilisation as all the philosophers, and infinitely more than all the politicians. As an Institute we have inherited great traditions of service of which we may be justly proud. We have also an heritage of responsibility to the past and to the future, which we cannot ignore, and which should inspire us to greater and greater efforts towards the advancement and honour of the profession to which we have the privilege to belong.

Dr. Brownsdon, in the course of his presidential address to members of the Birmingham Metallurgical Society, dealt primarily with the ideal relationships which ought to exist between the members of a scientific society and the society itself. He pointed out that many of the difficulties standing in the way of a scientific society's progress could be traced more to the specialised individuality of the members rather than to any inherent weakness in the constitution of the society. He pleaded, therefore, for a broadening of the members' interests in directions quite outside those of science.

The report of the Tariff Board on the Australian Government's preference policy has been laid before the House of Representatives. It strongly supports the increase in the proportion of British labour and materials to qualify for preference from 25 per cent. to 75 per cent., and states that the effect will be to benefit British as well as Australian industries. The Board is of opinion that if the other Dominions acted in similar fashion, Great Britain could make full and advantageous use of her raw materials. The Australian Association of British Manufacturers opposes an increase in the proportion to above 50 per cent., as it would occasion considerable hardship to many British manufacturers.

XUM

The Selling of Castings.

BY VOYAGEUR.

It is not realised with sufficient force by manufacturers of castings, whether non-ferrous or otherwise, that a considerable amount of research and hard thinking must be put into the selling of castings if a foundry is to pay its way. Too frequently the production side of a business is stressed at the expense of the distributive side, and it is this that leads to overproduction, high overhead expenses, and all the accumulated wastes of selling. It is not denied that in the face of certain factors of competition the finest selling schemes will often fail to produce a volume of trade large enough to keep the foundries running at top pressure; but the fact remains that, whatever be the state of trade at a given moment, the foundry that combines with scientific and efficient methods of production equally scientific and efficient methods of distribution will have as its reward a larger share than its competitors of whatever trade is offering.

This factor of distribution comprises far more than merely despatching goods from the works. It includes every step, every plan and activity, resulting from the operation of transferring goods from the manufacturer's works to the hands of the consumer. If, as some idealists advocate, all industries were State-controlled, this business of getting goods into the consumers' hands would not concern the founder at all. He would simply have to produce to the best of his ability, and the State would distribute the output of his foundry as it pleased. But in the world of industry as it is to-day, this work of selling falls under the category of works' organisation, and to fulfil it successfully, the manufacturer has to exercise initiative, foresight, and judgment; to display energy; to create his own markets. An endeavour will be made in this and future articles to discuss the best methods of selling castings, to suggest practical means for bringing manufacturer and consumer together for their mutual benefit. In short, to give in detail a *résumé* of the best modern methods of marketing, with special reference to castings.

The subject to be covered is a vast and complex one. Selling can be separated into three principal sections: analysing the market: preparing the selling policy; and executing the selling-policy.

Analysing the market is, perhaps, the most urgent of all three sections, because unless the manufacturer is thoroughly familiar with the right class of customer, the geographical position of these consumers, the amount they can consume in a given time, the exact character of their requirements, and the special needs he will have to satisfy, he cannot regulate his production properly, and will waste much money in purely speculative efforts to sell. It must be clearly laid down that the essence of efficiency in modern distribution is to cut out speculative production and speculative selling. Planning must take precedence over guesswork. But not only does analysing the existing and known markets cover the items already enumerated, it also includes seeking new markets altogether, gauging the extent and character of competition, experimenting in limited fields in order to discover the ideal selling scheme, and many other activities that will be detailed later.

Preparing the selling policy is the preliminary to the carrying out of the selling activities proper. The selling policy is essential to a sound marketing scheme, and can be likened to the plan of campaign with which a general opens a battle. The selling policy is based upon the results of the market analysis, and it unifies all the activities that follow. Some example of a selling policy is needed here to point these remarks. Let us assume that as a result of his investigation into the markets, actual and potential, for castings made from a new alloy, the founder decides that his best means of attack is to offer a trial casting to every consumer free of charge, on condition that the trial is carried out fairly, and that if successful a written notification to that effect shall be sent by the user. This becomes then the selling policy, and it will influence all the later selling activities. It will be the point to which travellers will try to bring their clients in interviews; the offer will be proclaimed in advertisements and circulars; it will figure in catalogues and other literature; and, in short, it will colour every attempt to sell goods to the customer. The written letters obtained by its means will be reproduced and quoted here, there, and everywhere. Until the selling policy is changed and another substituted for it, it cannot but affect every distributive method. The importance of the selling policy cannot, therefore, be overestimated.

Many firms, of course, have selling policies in practice, though they do not know it, and have never consciously thought about it. Others have no selling policy at all, and consequently both are less efficient than they might be. In the first case, though a firm may work to a definite plan or policy in its selling methods, and though it may be doing very well, it does not know for certain, unless it has properly examined the market, whether its plan is the best that could be followed. It may be good, but not good enough. In the second case a firm that has no policy at all sells haphazardly, misses opportunities in every direction, and is consequently continuously exposed to the vicissitudes of unspecialised trading. A selling policy makes every activity, both of production and distribution, coherent and controllable. It prevents energies from being dissipated, it teaches the whole organisation what to strive for, and produces true team-spirit.

The third section, executing the sales policy, covers the vitally important matters: selling by salesmen, by advertising, by circularising, by sales literature, by exhibitions and fairs, by overseas agencies, by co-operative methods, and so forth.

It must not be assumed that the order in which these three sections are given is the order of their importance. Each is as important as the other, and complete efficiency is only obtained when adequate attention has been paid to all three. But although the machinery of selling, *i.e.*, analysing the market, selecting the sales policy, and executing it, has been described, it must not be forgotten that this machinery cannot function without a motive power to drive it. This motive power is provided by the sales department of the firm concerned. It follows, therefore, that the first step towards the attainment of efficient sales methods is the organisation of a good sales department. This again is a subject that demands specific treatment, and what the writer seeks to do here is chiefly to emphasise the need for sound selling methods in the foundry trade. Once this has been granted, closer attention will in all probability be paid to the recommendations to be put forward in subsequent articles. The truth is that competition in the future is likely to grow keener rather than weaker, and whether this competition be unfair in character or not, there is only one way in which it can be met: first-class production allied to first-class marketing methods.

Foundry Statistics.

The production of pig-iron in Canada in August amounted to 23,072 gross tons. This output, 49 per cent. less than the 45,480 tons produced in July, was the lowest tonnage reported for any month since the commencement of monthly records in 1917.

Foundry and malleable iron registered substantial increases, but this was more than offset by the drop in the quantity of basic pig-iron produced for the further use of the reporting firms. This grade fell 83 per cent. to 5,942 tons, while foundry rose 71 per cent. to 11,911 tons and malleable iron advanced 54 per cent. to 5,220 tons. The average monthly production of 62,000 tons for the eight months ending August, although less than the 1923 average of 76,000 tons for the same period, exceeded the 1922 and 1921 averages when the quantities were 31,000 and 52,000 tons respectively.

During the month two furnaces were banked at Sydney, N.S., leaving two furnaces active at the end of August, namely, one at Hamilton, Ont., and one at Sault Ste. Marie, Ont.

Space-Factor Rate *v.* Hour Rate in the Allocation of Overhead Charges.

By Ecossais.

With trade in a normal state and healthy competition prevailing, as distinct from the present period, and the boom period of 1920, it is necessary, when preparing estimates, that these should be such as will provide a reasonable profit, in addition to covering actual cost of production, in the event of securing the contract. Although some firms will have heavier charges proportionately to others, the general prevalence of sound estimates on above lines would tend to stimulate efforts towards greater efficiency generally, as with the same charges the variations in estimates would not be great, and would be directly due to efficiency variations.

As the lowest price invariably secures the contract, no efforts should be spared to ensure that this is the lowest possible, commensurate with fair returns for profit, so that there need be no misgivings and regrets at not securing, by being underquoted, what would amount to an undesirable job, at any lower figure. To get the lowest price for a jobbing foundry equipped and manned for all classes of work calls for more searching information than is often obtained, as in all cases overhead charges must be recovered, and if these are not correctly allocated, a firm is running the risk of securing a greater proportion of the contracts undercharged in that respect. It is not unknown for a firm to be working all year with a full shop (not necessarily full of men) on apparently paying jobs, and at the year's end show an adverse balance.

Or the other way about with apparently poor jobs, but plenty of men fully employed a large surplus may be realised, in both cases due to faulty estimates.

It is with due consideration to these points, therefore, that the writer approaches the subject, with suggestions for the correct allocation of overhead charges; such that whatever grade of castings are included in the contracts and in whatever proportion they occupy the foundry floor, a full shop will mean that overhead charges are covered, neither more nor less, all labour and materials paid for, and the profit included in the estimate actually realised, instead of going to the relief of a defective estimate.

As it is not possible in an article to give actual figures, certain figures given below have been assumed for the sake of making comparisons, using some typical formulæ.

The case assumed is of a jobbing foundry, treated as a unit separate from pattern shop or other departments of the same firm, where work done by one department is credited to it and charged against the department concerned and receiving the goods. Details are purposely avoided as to the composition of the figure given for overhead charges, as each firm will have its own figures and their origin, if desirous of checking the suggestions dealt with in this article. It is sufficient to say that the figures given are supposed to cover all expenses normally incurred, other than labour, cost of metal and its melting, including repairs, and other charges which are incidental to a particular order.

Normal Weekly Charges and Figures.

Description.	£	s.	d.
Overhead Charges	120	0	0
Normal labour costs not including furnace labour	260	0	0
Normal Moulding and Coremaking costs (included in above)	135	0	0
Normal Molten metal cost (capacity 80 tons)	500	0	0
Area of foundry floor available and clear for moulding and all served by cranes	880 sq. yds.		
Hours in working week	50 ,,		
Normal moulding and coremaking hours	2,200 ,,		

Although there are several varieties of formulæ in use for compiling estimates, these resolve themselves essentially into about three types, those of any one type only varying in the amount of detail; all types in the complete form providing for profit, contingencies, haulage and incidental expenses.

In one type overhead charges may be based on normal direct labour costs; in another on the normal weight produced; while in another a compromise may be effected by splitting up the overhead charges and distributing them over normal labour and weight of production. Leaving out all details all three types may be represented by the same symbols, with different meanings as L + M = cost to foundry.

In the first type L would include cost of labour + overhead charges, and M = the cost of metal molten and furnace labour and repairs.

In the second type L would include labour only, and M = the cost of metal molten, furnace labour and repairs and overhead charges.

In the third type L may include labour and a proportion of overhead charges, and M = the cost of molten metal, furnace labour and repairs and a proportion of the overhead charges.

A modification of the first type intended to show the overhead charges as a separate item would be L + O C + M = cost to foundry, when L = labour cost; and O C = a percentage of L, or a rate per hour, for overhead charges, and M = the cost of molten metal and furnace labour and repairs.

Many firms may not profess to use any formula, but their estimates are arrived at, even if unconsciously, by one of the above or some modification of these.

In all cases, the results are apt to be incorrect in the event of variations in the grade of castings produced, by a change in the possible weight of production or the number of productive hours possible.

A shortage of orders and a portion of the shop empty does not reduce overhead charges materially, though prices obtainable at such times tend to get lower, creating a paradoxical effect in that a smaller volume of trade has to bear a greater proportion of overhead charges, which, however, it is not possible at such times to recharge to the customer. As pessimism is not a good business maxim, a full shop is always assumed, such fluctuations being met by the provision of reserves, the optimist awaiting the chance of a boom in trade for the replenishment and building up of further reserves; meantime obtaining existence prices in poor times, and exorbitant prices in the good times. It is, then, with the hopes of a full shop continuously, therefore, that the allocation of the overhead charge is made, on some assumed definite basis.

Using direct labour as the basis, the charges may be sub-divided so that by taking account of all actual labour, as moulding, coremaking, general labour and dressing at an estimated price per hour for each section to include overhead, the whole being grouped together under the symbol L for labour, the overhead charges on any particular casting or batch may be charged; such that when a certain number of hours of each section have been accounted for over a certain period, the overhead for the whole of the shop will have been recovered. This sub-division can be carried to excess and may require the services of a chartered accountant to retain a grip on it, to such end, in fact, that any advantage of the perfection of subdivision is outweighed by the disadvantage of the expense entailed.

There is, however, a medium, with the possibility of greater sub-division for special jobs, but so far as jobbing foundries are concerned it is often difficult to ensure that details are correctly obtained. For instance, a labourer may be employed on one mould for a fairly lengthy period, or may assist on 50 or more different jobs in a similar period, and in a different proportion of the time on each.

Therefore, for the purposes of this article, the higher paid branches, moulding and coremaking, being often equal or nearly so, are considered as direct labour. Reverting to the question of formulæ it is necessary to put a certain value per hour and per cwt., and a separate rate for addi-

TABLE I.—*Data and Comparisons, using Space-Factor Rate and Hour-Rate Methods of Allocation of Overhead Charges.*

Grade.	1	2	3	4	5	6	7	8	9	10	11	12	13	Grade.
Weight each .. ..(Cwts.)	18	16	20	12	10	7	24¼	7	5	40	80	60	17½	Weight each.
Moulding and coremaking. Hours each ..	10	10	10	10	10	72	35	10	17	31	100	125	175	Hours each.
Area in sq. yards occupied by each ..	27	16	16	11	8	16	21	15	8	54	54	20	13	Sq. yards each.
Possible output per week	163	275	275	400	550	38.15 × 2	59.85	293.3	323.5	26.28	8.15 × 2	17.6 × 3	19.3 × 4	Output per week.
Total weight per week .. ..(Cwts.)	2,916	4,400	5,500	4,800	5,500	534.1	1,466.3	2,153.1	1,617.5	1,051.2	1,304	3,168	1,351	Cwts. per week.
Moulding and coremaking. Hours per week	1,630	2,750	2,750	4,000	5,500	5,494	2,095	2,933	5,500	814	1,630	6,600	13,510	Hours per week.
Space factor. Sq. yds. × hours each ..	270	160	160	110	80	1,152 ÷ 2	735	150	136	1,674	5,400 ÷ 2	2,500 ÷ 3	2,275 ÷ 4	Sq. yd. hours each.
Overhead charges per casting—	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	
Sq. yd. hrs. × .66d = S ..	14 10	8 9½	8 9½	6 0½	4 4½	31 8¼	40 5	8 3	7 5¾	92 0¾	148 6	45 10	31 3¾	Sq. yd. hrs. ×.66d.=S.
Hrs. × 1s. 1¼d. = OC ..	11 0½	11 0½	11 0½	11 0½	11 0½	79 6	38 7¾	11 0½	18 9¼	34 2¾	110 5	138 0½	193 1¼	Hrs. × 1s. 1¼d. = OC.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	
Amount recovered weekly by S ..	120 17 10	120 17 8½	120 17 8½	120 16 8	120 17 8½	120 17 9	120 18 11¼	120 19 9	120 19 6	120 19 4½	121 0 0½	121 0 0	120 15 8¼	Recovered weekly by S.
Amount recovered weekly by OC ..	89 19 9½	151 16 5½	151 16 5½	220 16 8	303 12 11	303 5 10¼	115 12 11½	161 18 6	303 2 11¾	44 19 6½	89 19 9½	364 7 6	745 7 7½	Recovered weekly by OC
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	
Labour and metal only. Cost each ..	136 0½	123 6¾	148 6¾	98 6¾	86 0½	213 3	235 6¾	67 3¾	71 3¾	322 11¾	735 5	669 3¾	521 4¼	L + M.
Do. do. + S	150 10½	132 4	157 4	104 7	90 5¼	244 11¼	275 11¼	75 6¼	78 9	415 0¼	883 11	715 11	552 7¾	L + M + S.
Do. Price per cwt.	8 4½	7 10½	8 3¼	8 8½	9 0½	35 0	11 3¼	10 9¼	15 9	10 4½	11 0½	11 11	31 7	Price per cwt.
Labour and metal + OC	147 1	134 7	169 7	109 7	97 1	292 9	274 2	78 4	90 0½	357 2½	845 10	807 3½	714 5½	L + M + OC.
Do. Price per cwt.	8 2	8 5	7 11¾	9 1½	9 8½	41 10	11 2¼	11 2¼	18 0	8 11¼	10 7	13 5½	40 10	Price per cwt.

tion of overhead charges based on hours or cwts., as the case may be.

Taking the formula in type I, L + M = foundry cost, and using the assumed charges given previously

Direct labour cost per hour =

$$\frac{\text{Total labour costs + overhead charges}}{\text{Total hours moulding and coremaking.}}$$

$$= \frac{\text{£260 + £120}}{\text{2,200 hrs.}}$$

= Approximately 3s. 5½d. per hour.

The cost of metal per cwt. is =

$$\frac{\text{Total weekly cost metal, power, fuel, furnace labour and repairs.}}{\text{Weight in cwts.}}$$

$$= \frac{\text{£500}}{\text{1,600 cwts.}} = \text{6s. 3d. per cwt.}$$

So that assuming that 2,200 hours moulding and coremaking fully employed, and a production of 1,600 cwts. of castings per week, are the *actual* figures in practice, overhead charges will have been covered.

Whenever it becomes impossible to put into the foundry 2,200 hours moulding and coremaking, there will be a deficiency in overhead charges recovered.

Similarly with metal, though in less degree, the price per cwt. will increase as the weight falls below 1,600 cwts. per week, as furnace labour will remain approximately similar to a certain point, the melting ratio will be reduced and power and repairs will cost relatively more.

From the example under type 1 it will be clear how to obtain values for use in the second and third types of formula. In order to obtain the assumed overhead charges as a separate charge per hour, and for comparisons which will be made later, the weekly overhead £120 is divided among the 2,200 hours, giving a figure of 1s. 1¼d. per hour.

The previous figure, 3s. 5½d. per hour, includes overhead charges, and 1s. 1¼d. per hour represents overhead charge *only*, so that 2s. 4¼d. per hour will represent labour without overheads.

Metal will be taken at the estimated figure of 6s. 3d. per cwt.

The formula L (hours at 2s. 4¼d.) + O C (hours at 1s. 1¼d.) + M (cwts. at 6s. 3d.) = foundry cost, will now serve in the comparisons intended. as one example.

As before stated, "hours possible" may vary, also, "weight possible," may vary, and, as it is impossible to foresee which estimates will be accepted, and the jobs that may be occupying the shop at some future period, it is proposed to test the formula with trial estimates, on various types or grades of castings, and then assume that the foundry was engaged solely on any individual grade.

At the outset we are now compelled to consider the *area occupied* in addition to hours and weight taken.

This is not provided for in the formulæ previously considered, but the defect, due to absence of any such provision, at once becomes apparent.

In Table I is given several grades of castings which come within the writer's experience, giving essential particulars, area occupied, and, by taking the product of area occupied by hours occupied, a space factor, to render it possible to calculate the number of castings of any grade that will be within the capacity of the foundry with normal conditions of working.

It is not supposed that any foundry would actually be occupied in such a manner, but there is the probability of two or three grades only being secured, especially if the estimates are defective.

It is obvious that with any of the grades the overhead charges per casting will be equal to $\frac{\text{£120}}{\text{Number cast}}$ and that any amount above or below this figure will mean respectively losing or securing the job quoted for on this figure.

The value of the unit of floor-space used (sq. yd. hour) is obtained as follows:—

$$\frac{\text{Overhead charges (£120)}}{\text{Area of foundry floor (sq. yds.) × hours in working week (50)}}$$

$$= \frac{\text{£120}}{880 \times 50} = \frac{\text{£120}}{44{,}000}$$

or approximately 0.66d. per sq. yd. hour.

In every instance, with each of the two formulæ, labour and metal costs are on the same basis so as to confine the comparisons to the amount of overhead charges recoverable under each formula. Thus:—The formula L + O C + M = foundry cost, provides for recovery of overhead at a fixed rate per hour as *O.C.*, being 1s. 1¼d. per hour.

The formula L + S + M = foundry cost, provides for recovery of overhead at a fixed rate per sq. yd. hour as S, being 0.66d. per sq. yd. hour.

The area taken for any particular job may be in many cases twice the actual area occupied by the pattern, and is the average area required each, in which the job can comfortably be made.

Having determined the value of this in sq. yds., it is multiplied by the number of moulding and coremaking hours, giving a space factor in sq. yd. hours, which again multiplied by 0.66d. gives the amount to be charged for overhead.

With 2, 3 or 4 men engaged on one mould the space factor is divided by the number so engaged, as the time that that particular floor is occupied per mould is thus reduced, and the possible output of the floor increased. Instances of this are given in the cases of Grades 6, 11, 12 and 13, where respectively, 2, 2, 3, and 4 men are engaged on each mould.

In practice, increasing the labour does not increase the output in the same proportion, but this has been assumed for convenience in the examples given.

The possible number of any casting that can be produced is obtained by dividing 44,000 (sq. yd.-hours available per week) by the space factor of the casting in question.

The great variation in the number of moulding- and coremaking-hours possible per week is remarkable, and serves to illustrate the possibility of having a full shop and only half the normal moulding hours or a full shop and double the normal moulding hours.

This variation is the reason for the high estimated costs in each grade except Nos. 1, 7, 10 and 11 which are low, shown by comparison of the amount recovered weekly on the hour basis, as O C, with that recovered weekly on a floor space basis, as S, as also in the relative prices each and per cwt., at the bottom of the table, for S and O C.

The total weight possible per week would, in several cases, and if worked singly, be beyond the capacity of the melting plant, but this need not cause alarm for the reasons before stated, that is not assumed that any foundry, catering for the whole of the grades set forth, would be engaged exclusively on only the heavier types, as correct prices would ensure securing orders from all grades and extra weight might prove an advantage at times for helping the melting ratio.

Taking two foundries of same capacity, and each equipped for taking any of the 13 grades referred to in Table I, based on floor space, the other on hours, it is obvious that on price alone the floor space estimates would secure 9 of the grades, the hour base estimates getting the remaining 4 at prices with which they could not afford to continue in business.

It may be quite reasonably assumed that the price per hour (2s. 4¼d.) at which moulding and coremaking has been assumed is not sufficient in some cases, on account of extra work as dressing or labouring, and *vice versa* in other cases.

These would be the cases calling for sub-division of labour charges, but do not interfere in the comparisons made in the table, as, whichever job or formula is considered, the labour cost is the same for the same grade.

In conclusion the writer recommends jobbing founders to make comparisons of their own products, on the grounds that a casting requiring 50 sq. yds. for 10 hours' moulding is more expensive to produce than one requiring 10 sq. yds. for 10 hours' moulding.

Maxims for Moulders.

Better a fin than a crush; better be sure than sorry.—*Buchanan.*

"Chance-it" is dead; "short-cast" killed him. —*Buchanan.*

Sheet Metal Work *v.* Castings.

By J. McL.

If we are to believe a writer in a contemporary, the sheet metal worker is going to be a keen competitor with the foundryman for much engineering work in the future. The case against castings is that there is always a loss due to blow holes, cracks, warped surfaces, cold shuts and excessive hardness, and the scrapping does not occur until after expensive machining work has been performed on them. Well, no foundryman would claim that the production of castings is, or ever will be, an exact science, but there is a very large class of work that could be done by sheet metal which the engineer prefers to have as castings.

There is not really any competition between sheet metal work and castings. Punchings and stampings may, in some cases, be substituted for castings when large numbers are required, but this would have been done thirty years ago had it been possible, and this chiefly because of price considerations. For one-off jobs the casting is invariably preferred because it is cheaper, equally reliable unless when the metal is very thin, and more rigid. Let us consider, briefly, one or two jobs that one would consider might be better made as forgings, yet are not. When cylinders, condensers, or other engine parts are fractured and have to be patched, the pattern-maker is brought on the job, and he makes a model, to place, of the required casting. These may be ⅜ in. or ½ in. thick, and the patch is usually fastened with screws. Such a job is cheaper as a casting than as beaten work.

It is not usually necessary to make a template for patches of this kind, indeed, a template is not usually helpful, because the pattern may have to be bedded into an irregular shape. A sheet-iron worker requires templates to work from.

The writer has made many T and L section pieces several feet long, in his time, for ship work. It is not, in many cases, possible to design these in the drawing office before the vessel is well under way. There are not, as a rule, any marked surfaces, but chipping strips may be cast on. Even when a really close-fitting surface is not wanted chipping strips are advisable to obviate the need for camber, as castings of this kind are liable to warp. A pattern can be very quickly made and cast. In many cases the cheaper way is to make a pattern in the first case, but there are often reasons why this is not possible. The job may be in the bilges or on deck, and it may be in the most awkward position imaginable, as with the average engine-room job it is frequently more convenient to make a template from which a pattern can be made in the shop and subsequently tried to place. Even when it is not necessary to make a template it may be expedient to do so because other workmen may be on the way. A squad of riveters, for instance, may be induced to stand on one side for a few minutes while a template is being fitted, but not longer. A sheet-iron worker would require to work from a template also, and probably have to make several visits to the shop. Most of the work that can be made in sheet metal is without cores, and the thickness is, in the majority of cases, uniform: this means that the danger of castings being defective is minimised.

Too much importance can be attached to the brittleness of castings—even of grey iron castings. There is very little probability of a casting being broken in handling after it is marked. The castings discussed above have been one-off jobs, but, even for repetition work, unless of the simplest kind, castings are comparable with forgings or sheet metal work. The non-ferrous foundryman has certainly more reason to fear the competition of the die-caster. One might almost think, from the article already referred to, that for motor car work, as for range work, stampings were taking the place of castings for most of the parts. The scope for forgings is very limited, but apart from the necessity for castings because of intricate cores, there are other reasons why they are preferred, and the loss from breakages is not as severe as is sometimes suggested.

[Germany is making composite pulleys from cast-iron hubs and spokes and the rims from sheet metal.—EDITOR.]

Trade Talk.

THE HULL CITY COUNCIL have reversed their decision to purchase German tramway rails.

COX & DANKS, LIMITED, have just raised the sixth German destroyer at Scapa Flow in record time.

THE IMPORTS of foreign iron-ore at the Senhouse Dock at Maryport last week amounted to 3,500 tons.

THE SILVER MEDAL at the Agricultural Exhibition, held in Reval during September, has been awarded to a Petter 8 h.p. oil engine.

DORMAN, LONG & COMPANY, LIMITED, have secured an order from Germany for 15,000 tons of steel plates. These will be rolled at the Redcar works.

IN THE FIRST nine months of this year 50 vessels of 192,785 total gross tons were launched from the Tyne shipyards. This is an increase of 12 vessels and 87,288 tons on last year.

A FUSION OF THE business of Martin, Hall & Company, Shrewsbury Works, the Park, Sheffield, and Gladwin, Limited, of Rockingham Street, is likely to take place in the near future.

SIEMENS & ENGLISH ELECTRIC LAMP COMPANY, LIMITED, have been successful in obtaining a contract for the supply of Siemens vacuum and gas-filled lamps to the Education Authority of Glasgow.

HARLAND & WOLFF, LIMITED, are at present building at the Queen's Island works, Belfast, a 30,000 h.p. Diesel engine, which will mark a big step in the development of this method of marine propulsion.

BARRHEAD WAS on Saturday the scene of a destructive fire, heavy damage being caused at the Grahamstone Foundry, of John Cochrane (Barrhead), Limited. Over two-thirds of the works have been ruined.

THE three firms concerned in the recent steel-workers dispute, at Sheffield, Steel, Peech and Tozer, the Park Gate Iron and Steel Company, and Samuel Fox and Company, were able to take on a fair number of men on Monday. The prospects are that within a few days most of the men will have been absorbed into full work again.

THE 62-TON electric generator, made by the General Electric Company, Limited, of Witton, Birmingham, for St. Marylebone Council, reached its destination in London on Wednesday morning of last week after its 110 miles journey by road. The journey was naturally of a most difficult character, and even when St. Marylebone was reached a projecting bolster had to be removed before the generator could be moved into position in the power station.

THE LONDON & NORTH-EASTERN RAILWAY COMPANY have placed a contract with Fullerton, Hodgart & Barclay, Limited, Paisley, for four electrically-driven three-throw hydraulic pumps, fitted with variable speed motors. Each pump will be capable of delivering 90 gallons per minute to 750 lbs. pressure per square inch. Two sets of these pumps are required for the company's power station at York, and the other two for the company's power station at Newcastle-on-Tyne.

THE WORKS OF George Turton, Platts & Company, Limited, are at present well employed, the Meadow Hall Departments and the Furnival Road Stamping Department working night and day. The progress made by the Meadow Hall Works has been particularly encouraging, and the volume of buffer orders on the books is now larger than at any period during which these works have been in operation. Two contracts now in hand for 6,500 and 4,500 complete buffers of the large Indian type may be specially mentioned in this connection.

VICKERS, LIMITED, are actively engaged on the development of a large Diesel engine for fast passenger ships. The company were the originators in this country of the Diesel engine for submarine boats, and since they first commenced their manufacture they have turned out engines of no less than half-a-million brake horse-power. The motor-ship "Moveria," which has just been launched for the Donaldson Line, will be propelled by the largest internal combustion engine of commercial type built at Barrow, having larger diameter cylinders than those of any other 4-cycle engine.

COMPLAINTS HAVING BEEN MADE that the port of Southampton is lacking in some of the facilities required by the great liners, the Southern Railway Company have authorised an almost immediate start with the construction of new deep-water jetties and approach channels which will provide accommodation for the largest ships now in service. The scheme involves the reclamation of about 460 acres of mud lands which form a bay about two miles long and half a mile wide in the river Test between the Town Pier and Southampton West station. From the new river frontage thus created the complete scheme provides for the construction of five reinforced concrete jetties, each 1,000 ft. in length and 260 ft. wide, with a depth alongside of 45 ft. at low water of spring tide

Gazette.

MR. A. SMITH, trading as Smith & Company, Cookridge View, Horsforth, Leeds, metal merchants, has been adjudged bankrupt.

A RECEIVING ORDER has been made in connection with the affairs of Mr. E. Holden, Dial Lane, West Bromwich, drop forging manufacturer.

THE CALLIM METALLURGICAL COMPANY, LIMITED, are being wound up voluntarily, with Mr. G. Chich, secretary of the company, as liquidator.

A WINDING-UP ORDER has been made against the Planet Engineering Company, Limited, Eccles New Road (near Stott Lane), Pendleton, Salford.

THE FIRST MEETING of the creditors of the Birchfield Foundry Company, Limited, Chain Walk, Birchfield, Birmingham, will take place to-day (Friday).

MESSRS. J. H. VICKERS and R. TOZER, mechanical engineers, 11, New Street, Sheffield, trading under the style of Vickers & Tozer, have dissolved partnership.

MR. A. P. VERNON-HOPE and MR. G. LISTER, JUNR., trading as William Poulton & Company, Brantwood Steel Works, 30, Wilson Road, Sheffield, have been adjudged bankrupts.

THE NORTHUMBRIA ENGINEERING AGENCIES, LIMITED, 86, Pilgrim Street, Newcastle-upon-Tyne, are shortly paying a dividend, the last day for receiving proofs being October 22.

THE THOMPSON ENGINEERING COMPANY, LIMITED, are being wound up voluntarily. Mr. F. S. Oliver, 32, Grainger Street West, Newcastle-upon-Tyne, has been appointed liquidator.

THE LAST DAY for receiving proofs in connection with a dividend to be paid by Mr. J. G. Ellwood, White House Colliery, Egglestone, Co. Durham, colliery owner, is October 22.

MESSRS. W. H. VEVERS, JUNR., W. ROOK, and F. W. SAMMONS, bell engineering smiths, Bell Street, Maidenhead, trading under the style of the Bell Engineering Smithy, have dissolved partnership.

Personal.

MR. J. M. DEWAR has been elected a director of Chadburns (Ship) Telegraph Company, Limited.

MR. E. W. PETTER, the president of the British Engineers' Association and chairman of Petters, Limited, has left England on a business visit to Canada and the United States.

MR. JAMES THOMPSON, one of the principals of the firm of Messrs. John Thompson, boiler makers, Ettingshall, Wolverhampton, has been elected an Alderman of the borough of Wolverhampton.

MR. J. BARR, special director of Vickers, Limited, Barrow-in-Furness, has been elected president of the Shipbuilding Employers' Federation, in place of Mr. Grant Barclay, of the Caledon Shipbuilding and Engineering Company, Limited, of Dundee, retired. Mr. A. J. Campbell, of Wm. Beardmore & Company, Limited, Dalmuir, has been elected one of the vice-presidents.

Wills.

ELLISON, H., of Grange Crescent, Chapeltown Road, Leeds, iron and steel merchant £9,054

MEGGITT, S. N., of Inglewood, Southbourne Road, Sheffield, for many years a director of Ibbotson Bros. & Company, Limited, of the Globe Steel Works, Sheffield £16,810

The Cubic Centimetre.—The Joint Committee for the Standardisation of Scientific Glassware has recommended the abolition of the cubic centimetre. It seems that this unit, or rather the volume occupied by 1 gramme of water, is one five-hundredth part as great again in volume as it claims to be, and 1,000 c.c.s., measured on the assumption that the weight of one cub. centimetre of water is one gramme are really equal in volume to 1.002 litres. The new unit to succeed the cubic centimetre is to be the millilitre (the "ml."), which will really be the one-thousandth part by volume of the standard metric litre. Recognising the difficulty of expelling the cubic centimetre from our laboratories, the Committee recommends its use under the symbols "G. W. A.," which mean "grammes of water in air." The reform has already been largely accepted by other countries, notably America. It arises from the fact that although the kilogramme was originally conceived as the mass of a quantity of water, which, at its temperature of maximum density, occupied a cubic decimetre, it is in reality the weight of a standard kilogramme made in 1872, which does not quite fulfil the above conditions.

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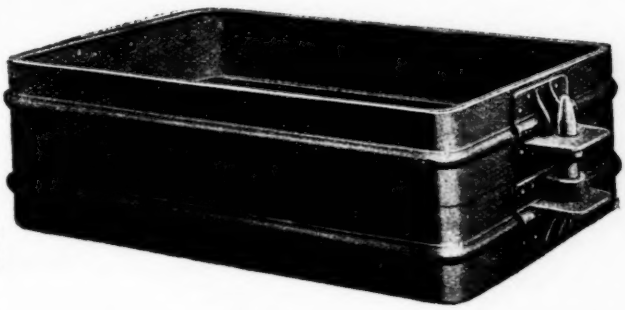

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IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—Business in the Cleveland iron market, though without material change during the past week, has certainly regained a steadier tendency, and hopes are now entertained that, prices having reached a more stable position, buyers will adopt a more confident attitude in relation to forward contracts, a policy for some time past in abeyance. A few forward sales have, indeed, already been effected. The output is small, stocks are not heavy, and a little more trade activity all round could hardly fail to stiffen values. At the moment, of course, there is no disposition anywhere to undertake fresh commitments until the General Election is over, and the political outlook is a great deal clearer than it is at the present time. After that the opinion is generally held in business circles that, provided there is some promise of stable government, business should open out.

LANCASHIRE.—The position in the local market for foundry pig remains in an unsatisfactory condition, with buying almost invariably confined to retail quantities. For a very long time consumers of pig-iron have found it profitable to buy from hand to mouth and to put off any purchases until the last possible moment, and this policy is now likely to be pursued, at any rate for the remainder of the present year. It is difficult just now to say exactly what is the price of No. 3 foundry iron in Manchester, the quotations of different sellers varying considerably. For instance, there are brands of Derbyshire iron which are still held for 92s. per ton in Manchester, but probably a more general quotation is 90s. It is, however, fairly certain that if Derbyshire sellers are holding to 90s. other Midland foundry iron can be bought at less. Cheap Northamptonshire iron has been offering here, and there have been reports of this iron being offered at 76s. on trucks at the furnaces, or 4s. per ton below the price which was quoted before the drop in Midland coke.

THE MIDLANDS.—At Birmingham market last week buyers of foundry pig were few, and demand was only on a limited scale, the efforts of smelters to maintain prices on a more stable basis meeting with little success, while the tendency was weak. The lower figures for foundry iron have brought a little new business, but the volume of inquiry is abnormally low, with the prospects of early improvement rather remote. There are practically no inquiries for export. Current quotations rule as follow:—Derbyshire No. 3 foundry, 81s. to 82s. 6d.; Staffordshire No. 3 foundry, 85s.; Northants, No. 3 foundry, 74s. to 78s.

SCOTLAND.—Movements in the Scotch foundry iron markets have been further disturbed by political excitement, and business is on a very restricted scale. Many local foundries have done no work for several months, and, as time goes on, even those firms who have hitherto weathered the dull times are finding themselves forced into closing down now like their more unfortunate neighbours. The nominal price of No. 3 foundry remains at 90s. per ton at the furnaces, but it is well known that business is being taken at considerably below this, 88s. 6d. being quite a common figure for actual business.

Finished Iron.

In the market for finished material, although the price of crown iron has fallen to the extent of about 10s. per ton, due to the influence of outside competition, the orders coming forward are by no means encouraging, being of small tonnage and miscellaneous in character. Regular working is out of the question so far as the ironworks are concerned, and were it not for the comparatively good demand for marked bars the outlook would be disastrous. Marked bars are still quoted at £15 f.o.t. makers' works. Little support is forthcoming to the makers of nut and bolt iron, who quote £11 15s. for this grade. The bolt makers are very poorly placed for work, and carry heavy stocks of iron, chiefly of Continental origin. Belgian iron is being offered at £7 5s. to £7 10s., and these figures would be shaded under existing circumstances. Yorkshire and Cleveland bars are down 10s.

Steel.

The strike of steel workers at Rotherham and Sheepbridge having ended, practically all the furnaces in the Sheffield area are again working to make up for lost production. There is but a small demand for either basic or acid billets, but prices remain unchanged. Open-hearth steel is in very meagre request, and the inquiry for crucible steel, which improved recently, is now as bad as ever again. In some of the specially high-grade steels there is a slight upward movement in buying. In the market for alloys very moderate parcels of silico-manganese have changed hands, and the prices of the various percentages are very regular. The demand is normal and deliveries quite up to calls. A very moderate inquiry for tinplates has resulted in only a small proportion of business of late, buyers evidently holding back in anticipation of lower prices, as the bulk of the trade done lately has been almost entirely for near dates. Sales of second-hand parcels are reported at a shade under the official figure by merchants who bought before the last advance.

Scrap.

Very little that is satisfactory can be reported in connection with the markets for scrap material, which, at the moment, are in an exceptionally depressed condition, with small hope of an early recovery. The slackness in the Lancashire foundry industry has become accentuated, and consequently cast scrap is neglected; local consumers of this district are buying very little of it. Dealers quote 85s. per ton for good broken machinery iron, but it is rumoured that founders can obtain it at 82s. 6d., and there is common cast scrap to be had at 80s. In Scotland also similar conditions to the above are in evidence, with only a poor market for foundry material. Machinery cast-iron scrap is quoted 83s. 6d. to 85s. per ton. That is material suitable for foundries, and in pieces not exceeding 1 cwt. For ordinary quality to the same specification 80s. per ton, and for the larger pieces to steelworks specification 75s. to 77s. 6d. per ton. The above prices are all per ton delivered f.o.t. consumers' works.

Metals.

Copper.—Movements in the standard market last week were uneventful, values evidencing only a limited range of fluctuations with a firmer tendency towards the close. Home consumption of the metal is maintained at a steady average, while the speculative element in the market is less in evidence than previous experience would indicate. In America there is evidence of desire on the part of producers to attract buyers, and the quotations of selling agencies here and on the Continent have been generally below the parity of New York quotations. Current quotations:—*Cash*: Thursday, £62 7s. 6d.; Friday, £62 10s.; Monday, £62 17s. 6d.; Tuesday, £62 15s.; Wednesday, £62 15s.

Three Months: Thursday, £63 10s.; Friday, £63 12s. 6d.; Monday, £63 17s. 6d.; Tuesday, £63 15s.; Wednesday, £63 15s.

Tin.—Conditions in standard tin continue favourable, the position having firmed considerably on active buying. The outlook both in America and on the Continent is also regarded as more encouraging, and should the results of the elections on both sides of the Atlantic terminate favourably to business views, still firmer values would appear inevitable.

The world's visible supply at the present time is about 2,000 tons more than the figures for September, 1923, but in view of the dispersal of the "pooled" surplus in the East during the past twelve months and the fact that it will be all cleared out of the way in another few months makes the present position very interesting. Current quotations:—*Cash*: Thursday, £243; Friday, £245 10s.; Monday, £251 5s.; Tuesday, £250 10s.; Wednesday, £253 10s.

Three Months: Thursday, £245 15s.; Friday, £247 15s.; Monday, £253; Tuesday, £252 5s.; Wednesday, £255.

Spelter.—The market for this metal continues steady, with values inclined to firmer figures. The Continental manufacturers, although still holding for high prices, appear lately more inclined to meet the market. Meantime further purchases have been made from America. There is room for improvement in the current demand from consumers. Current quotations:—*Ordinary*: Thursday, £33 2s. 6d.; Friday, £33 6s. 3d.; Monday, £33 7s. 6d.; Tuesday, £33 13s. 9d.; Wednesday, £33 15s.

Lead.—The position of soft foreign pig remains practically unchanged, although the forward quotation has fluctuated but slightly since the tendency has been to improvement. September lead, on the other hand, at one time lost the major portion of its premium, the backwardation having been reduced to 5s. a ton. The Continental inquiry for lead is excellent. The position of the article appears to be strong, but the price is admittedly high. Current quotations:—*Soft foreign (prompt)*, Thursday, £35 12s. 6d.; Friday, £35 12s. 6d.; Monday, £36 5s.; Tuesday, £36 17s. 6d.; Wednesday, £36 17s. 6d.